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AN INVESTIGATION INTO THE FEASIBILITY
OF ESTABLISHING MANPOWER STANDARDS
FOR MAJOR AIR COMMAND ENGINEERING
AND SERVICES ORGANIZATIONS

THESIS

Mark H. Bailey, BSIE
First Lieutenant, USAF

AFIT/GEM/LSM/84S-2

DEPARTMENT OF THE AIR FORCE
AIR UNIVERSITY
AIR FORCE INSTITUTE OF TECHNOLOGY

Wright-Patterson Air Force Base, Ohio

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AFIT/GEM/LSM/84

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There currently exists no set of generic manpower standards universally applicable to Major Air Command Engineering and Services organizations. Abilities to accurately plan and program manpower requirements are severely impacted, utilization efficiencies are being missed, and manpower actions are being made without any quantifiable support.

This research attempted to develop a generic manpower standard for the Housing and Services Branch of Engineering and Services Deputates. Air Force Logistics Command, Air Force Systems Command, and Tactical Air Command were participating commands. Because of varying command structures, a modular approach was used to develop standards for categories of work. Work sampling techniques were used to gather manhour data as a percentage of time spent per day in various categories; this was later converted to manhours. The sampling consisted of recording observations of work categories at random times. Descriptive workload factors and their values were obtained by questioning participants. Classical, stepwise regression was used to develop descriptive models for each job category. Results were evaluated by combining the resultant of each model and comparing to present levels.

Many different workload factors were identified as potentially descriptive; they were significant from a relationship standpoint but not regression-wise. Many solid descriptors could not meet specified acceptance criteria. Extreme multicollinearity was present due to factor selection. The presence of heteroscedasticity did not permit adequate evaluation- even after using data transformations.

This research was not entirely successful, but it did prove the feasibility of standards development. It laid some preliminary groundwork to that end.

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AN INVESTIGATION INTO THE FEASIBILITY OF ESTABLISHING MANPOWER STANDARDS FOR MAJOR AIR COMMAND ENGINEERING AND SERVICES ORGANIZATIONS

THESIS

Presented to the Faculty of the School of Systems and Logistics

of the Air Force Institute of Technology

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In Partial Fulfillment of the

Requirements for the Degree of

Master of Science in Engineering Management

Mark H. Bailey, BSIE

First Lieutenant, USAF

September 1984

Preface

Working, developing, and producing a thesis is both a learning experience and an exercise. It is a learning experience in that one takes an idea and tries to extend the thought beyond the present bounds of knowledge — succeeding in some attempts and failing in others. A thesis is also an exercise in patience and futility; understanding and confusion; and academia and practicality. These feelings, emotions, or thoughts appear alternately but continually throughout the thesis process. The thesis process itself is something that is necessary to build one's confidence in his abilities and lets him know he truly has "mastered" something. A thesis, or at least the effort behind it, cannot truly be appreciated (if that indeed is the correct word) until it is completed. I cannot really say that I was completely overjoyed with developing a thesis but I can say I am overjoyed it is completed.

I have made the thesis effort sound as if it were totally individualistic; this is surely not the case. A thesis can only be produced through team effort -- that of the researcher, the advisor, the participants, and many others. I would like to thank everyone involved in this effort. I do not want to be remiss in thanking anyone; any exclusion is purely unintentional.

These individuals were key to the conduct of the entire research. I first broached the possibility of this research with them and because of their sincere and positive support and enthusiasm the project was undertaken. Many thanks to John Dixon, HQ TAC/DEMG, Capt Glenn D.

Haggstrom, HQ AFSC/DEMG, and Phil Ruud, HQ AFLC/DEMG. Lt Col Robert W. Swaney, HQ AFLC/DEH, and Maj Alan R. Oschsenbein, HQ AFLC/IGIS, contributed significantly to the research design and were instrumental in establishing the tested workload factors. They were superb points of contact and sources of information. Also acting as points of contact were Capt Deborah A. Dumont, HQ AFLC/DEH, and Capt Lori A. Reisdorf, HQ TAC/DEH, who conducted the survey within their respective commands. Without their untiring assistance to their additional duty, the research would not have progressed.

Maj Joseph W. Coleman was an outstanding instructor who taught me most everything I know about statistical analysis. He always provided expert guidance with methodological development and subsequent analysis. He provided support over the rough areas. He is the man who taught me the difference between multiple and multivariate regression. Maj Arthur L. Rastetter, my reader, always provided a fresh insight and perspective on the effort. He examined all aspects objectively and saw a way through many difficulties.

The man who always saw the light at the end of the tunnel and encouraged me to strive for it under any circumstances was my advisor, Maj Joseph C. Munter. He made significant contributions to this effort that are too numerous to mention. He identified many problems, weaknesses, and pitfalls that myself and others did not see. He strongly believed in this project and supported it to the maximum. He was, at times, a taskmaster -- but believe me, there is a payoff. Most of all, he kept me straight. Together we achieved something -- a first thesis for both of us.

I surely would never forget Jackie McHale. Jackie was the expert typist who took this effort and organized it into a perfect document. Many thanks to the lady who nearly went blind trying to interpret my chicken scratch.

Now, lets go fly!!

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Abstract

No set of generic manpower standards exist that are universally applicable to Major Air Command (MAJCOM) Engineering and Services deputates. Abilities to accurately plan and program manpower requirements are severely impacted, utilization efficiencies are being missed, and manpower actions are being made without any quantifiable support.

This research investigates the applicability of existing command-specific standards to all Engineering and Services deputates. If generalization were not appropriate, the research sought to develop such standards.

A pilot study of current staffing levels versus those recommended by the specific standard was conducted to determine applicability. It also served to identify directorate areas for future study as well as selecting commands to participate in the research. General applicability was not noted; the Housing and Services directorate and Air Force Logistics Command, Air Force Systems Command, and Tactical Air Command were chosen as study areas and participants, respectively.

Not every command was structured uniformly, so modular standards were sought. Modularity accounted for structural differences by developing an appropriate standard for categories of work. This way, a

universal standard could be developed as work categories were the same -- only in different alignments. Work sampling techniques were used to gather manhour data as a percentage of time spent per day in various categories; this was later converted to manhours. The sampling consisted of recording observations of work categories at random times. Descriptive workload factors and their values were obtained through questioning participants. Classical, stepwise regression was used to develop descriptive models for each category. Results were evaluated by combining the predicted manhours from each model for each command and converting the end product into a manpower level needed to support the specified number of hours.

Many different workload factors were identified as potentially descriptive. Most were statistically significant insofar as correlations were concerned but were not sufficiently significant from a regression standpoint. Data transformations were used to try and reverse the situation. No acceptable models were developed. Extreme multicollinearity was present and heteroscedasticity did not permit confidence interval estimation nor validation of untransformed data models. Transformed data greatly reduced identified relationships.

The development of generic manpower standards for MAJCOM staffs is certainly needed and is entirely feasible. This research, though not entirely successful, laid some preliminary groundwork in this area.

AN INVESTIGATION INTO THE FEASIBILITY
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I. Introduction

Manpower planning has been characterized as the key to the continued existence of many organizations. Today, with efficiency in operations so vital, manpower planning attempts to attain and maintain efficiency in organizational manpower requirements (12:32). A manager needs to be familiar with manpower planning concepts and techniques so that he may be efficient and effective in his operations.

> Manpower planning is a process that seeks to insure that the right number and kinds of persons will be at the proper place at the right times in the future in order to guarantee the attainment of the organization's vital goals and objectives [21:37].

> Manpower planning is also just good business . . . failure to plan is planning to fail . . . the lack of planning, like undiscovered termites, is not visible for sometime. Then the roof falls in [26:43].

These perspectives define the concept of manpower planning, serving to underline the idea of planning in the management of humans. Manpower standards are the vehicle that implements manpower planning in the Air Force. A manpower standard can be defined in terms of its

objectives: to develop a valid, descriptive work center manhour-to-workload relationship and to quantify this as a manpower requirement. These requirements form the basis for the effective use and efficient distribution of human resources within the Air Force (33:3-1).

Manpower standards identify minimum essential Air Force manpower requirements; they are the primary means of determining and programming future manpower requirements. These standards can also be thought of as tools used to determine requirements and allocate resources. The systematic implementation of manpower standards and their resultant manning authorizations are recognized by the Office of Management and Budget, Congress, and the Secretary of Defense. These functions of government view standards through their contributions to the Five Year Defense Plan (FYDP) and the Planning, Programming, and Budgeting System (PPBS) which form the basis of resource management control within the Department of Defense and thus the Air Force. The ability of the Air Force to obtain required resources is directly related to the FYPD, PPBS, and other management systems. Air Force inputs to these systems are in the form of manpower required to maintain a force while outputs pertain to staffings throughout commands. Manpower levels in these documents are those authorized for and allocated to all Air Force units. The importance of Air Force manpower standards is manifested in various management systems (37).

Problem Background

The concept of manpower planning is a by-product of World War II. The federal government, in need of rapid mobilization and development,

required ways to project industrial production so that production quotas could be met. Additionally, shortages of manpower made planning necessary, thus permitting the necessary distribution of human resources to critical industrial sectors. To achieve this, the government required industry to analyze their manpower situations and to develop programs to adequately staff all functions. Borrowing on these techniques and realizing the need for financial management, the Department of Defense published Directive 5010.4, entitled "Management Improvement Program" in 1951. Highly subjective tables of organization and equipment based on estimate and experience would no longer be acceptable as manpower management tools. Instead, the directive required each service to develop work measurement systems based on statistical procedures, historical data, and methods engineering and industrial engineering. Manpower planning techniques were developed to such a point in the 1960s that they were applicable to the work center level. Through the use of work sampling techniques, the manpower needed to perform a job could be measured and extrapolated to other similar work centers and jobs throughout the Air Force (40).

A review of Air Force Index 0-18, Index of Air Force Manpower Standards, shows that a generic standard has been developed for most functions. The use of the term generic means that the standards are universally applicable across units, installations, and commands by virtue of their derivation, composition, and application. Standards are applicable at the operating unit level; they are developed by functional accounts. The standards are used as management tools primarily at the wing level. That is, all the organizational

sub-elements below group or squadron level are composed of units for which a manpower standard exists. There are no generic standards universally applicable to all levels of an organization. One standard exists for a single major air command (MAJCOM); it is a specific, single-point standard suitable to only that location (32; 44).

These organization levels do not obtain their manpower authorizations by using the established scientific techniques; they use judgement, experience, and past staffing patterns. Von Wolffradt and Worrell's (40) research showed that judgement is an accepted manpower technique when no other method is available; AFR 25-5 series labels the technique as a technical estimate. In the absence of a quantitative manpower standard for a MAJCOM or a work unit such as a deputate, required manpower is determined through technical estimate or educated guess.

Effects of the lack of a general manpower standard for various deputates at the MAJCOM level can be seen in the problems it manifests. In the case of the Engineering and Services deputates, one problem has been the lack of flexibility. The Alaskan Air Command is currently experiencing a large increase in construction programs due to major mission changes. Organizational performance capabilities are degraded and effectiveness of the deputate staff is reduced because it must respond to changing mission requirements and increased workload with no complementary change in human resources. Likewise, when work requirements decrease, it would be inefficient to have a large number of personnel working on fewer requirements. Again, staffing levels are not geared to the mission and work requirements. The Alaskan Air

Command ideally demonstrates this case as the current increased work requirements experienced by the Engineering and Construction staff will be reduced when construction is completed. The workload would then be transferred to the Operations and Maintenance staff and the cycle would repeat. There are no provisions to accurately and adequately predict the manpower impact of future changes (11; 16).

Another problem is determining appropriate action when staffing cuts must be made. There is no guidance to reallocate resources. Currently, changes are being made based on estimates of the situation. Unfortunately, changes are sometimes made to areas that can least afford it while others go untouched. MAJCOM managers at all levels require a valid guide based on solid criteria. A valid guide would lend credence to manpower reallocation processes.

Attempts have been made in the past to develop specific, generic manpower standards for various deputates at the MAJCOM level. Most attempts have resulted in failure or less than optimal outcomes because of difficulties in generalization due to differences in organization structure or perceived organizational threats and political climate. A special services function is currently attempting to develop a manpower standard for MAJCOM manpower staffs (3). In 1975, HQ USAFE drafted a standard for their Engineering and Services organization but did not implement it (6). HQ AFRES completed an applications study of its Engineering and Services organization in December 1982; the study is currently awaiting implementation. The study is the first complete quantification of a MAJCOM Engineering and Services deputate manpower requirement. Their objective was to evaluate current organization

structure, validate authorizations required by current workload, and develop manpower standards to accommodate programmed changes. This study may not be universally applicable across commands because it is a single-point study (i.e., HQ AFRES/DE). Statistical and work analysis techniques used were appropriate for small sample sizes. Additionally, operational audit techniques of historical data and technical estimate were used and based on a sole sample point. Results could not be statistically validated (44).

Problem Statement

There currently exists no set of generic manpower standards that universally apply to all MAJCOM Engineering and Services deputates. Thus, abilities to accurately plan and program manpower requirements are severely impacted, utilization efficiencies are being missed, and manpower actions are being made without any quantifiable support.

Objective

The objective of this research effort was to investigate the applicability of the manpower standards developed by HQ AFRES across MAJCOM Engineering and Services organizations. If general applicability was not feasible, this research used work and statistical analysis techniques to develop a model that is descriptive of manpower requirements at this level.

The research hypothesis tested was that a general manpower model that is sufficiently descriptive of actual, required manpower can be developed for MAJCOM Engineering and Services deputates. In symbolic form,

$$H_o : \mu = b_0 + b_1x_1 + b_2x_2 \ldots + b_cx_c + e$$

$$H_a : \mu \neq b_0 + b_1x_1 + b_2x_2 \ldots + b_cx_c + e$$

when the model is in the form of a linear equation suitable for analysis using regression techniques.

μ = total manhours required to accomplish all tasks assigned to specific work center within a specific time period

b = the unit time, both described and undescribed by relationships, for all tasks assigned to specific work center within a specified time period

x = the volume of work, in units, accomplished during the period of study that corresponds to functions measured

e = the error resultant from model's descriptive limitations or resultant from data randomness

Specific Research Questions

Specific research questions investigated in support of the objective are:

1. Is the development of a generic manpower standard for all MAJCOM Engineering and Services deputates feasible?

2. How appropriate are the manpower standards developed by HQ AFRES for generalization?

3. What are appropriate workload factors for inclusion in a descriptive manpower standard taking into consideration the attainability, quantifiability, and sensitivity of various factors?

4. What specific equations are most representative of branch manpower requirements across MAJCOMS?

5. How valid are the manpower equations developed in comparison to current manning levels?

Scope

Factors affecting the breadth and depth of this study included determining which MAJCOMS, directorates, and branches should be studied as well as deciding the level of analysis for each grouping. MAJCOMS considered for study were limited to those within CONUS having a real property responsibility. This limitation was chosen because CONUS MAJCOMs comprise the majority of Air Force commands, have less extraneous factors affecting their operation, and require less lead time in a study. Additionally, there are some MAJCOMs that have little or no real property responsibilities as they are a one base MAJCOM or are generally tenants on installations belonging to another command; examples include Air University and Electronic Security Command. These types of commands do not present a true picture of the generic requirements of the Engineering and Services area. These commands meet the criteria specified above: Air Force Logistics Command (AFLC), Air Force Systems Command (AFSC), Air Training Command (ATC), Military Airlift Command (MAC), Space Command (SC), Strategic Air Command (SAC), and Tactical Air Command (TAC).

A pilot study based on the findings of the HQ AFRES study was used to determine which directorates and branches within selected commands should be studied. The study required each branch at each MAJCOM to apply the HQ AFRES models and compare to current authorizations. Variations between current and applied authorizations were earmarked for investigation. The pilot study served to narrow the functions to be studied. Not every functional area was considered, as some are

mission unique and not generally applicable across commands; these areas were identified for potential future study.

Level of analysis relates to the depth at which each function is examined. The first way a function could be studied is rather general and is based on the standardized organizational structure specified in AFR 26-2 and general job categories of AFR 85-7. A standard was determined by measuring the time required to perform a group of tasks. An in-depth analysis of each tasking, by work flow and volume, was the second possible level. This level required identification of each individual job performed and traced the sequence of steps to accomplish each tasking. Standards were determined by using the time required to complete each tasking and its associated volume of work. This investigation concentrated on the general job categories of each function since the approach was better suited for chosen methodology and the practical and time constraints placed on this study.

Research Justification

Justification for this research stemmed from factors already discussed. No manpower standards currently exist for most MAJCOM functions and more specifically the Engineering and Service deputates. Manpower standards provide direct input to the FYDP and the PPBS. The lack of a standard could result in inaccurate and invalid inputs thus causing inefficiencies in the DOD resource management systems. Not only is the required level of manning not identified, the level is also insensitive to changes in workload. When reallocations of workload are required, no empirical guide is available to assist the process. These

discrepancies represent the ineffectiveness of personnel management systems and inefficiencies in resource management.

Data Availability

Data to support this research was not presently quantified; it does not exist in an adequate form for analysis. Data regarding aggregate work time expenditures and units of work volume were surveyed and translated into times per job category. A sampling survey provided necessary raw data with little burden on the respondents. Potential difficulties lie with the motivation of those surveyed to provide accurate raw data as well as possible restrictions caused by Air Force survey and local union policies.

Methodology

Data was gathered by applying work sampling techniques. Work sampling was done by job categories as they are defined in AFR 85-7; each individual participant performed his own sampling. The raw data provided by sampling was transformed into time spent performing each category of work for every branch studied. When grouped with data describing potential workload factors, all data was regressed to develop appropriate manpower models. The regression was performed by category. The overall model was created by combining the independent modules.

Resultant models were evaluated by substituting respective workload factor values into them and dividing the result by the standard number of manhours in a month. Additionally, a prediction

interval around this value was developed. If the interval contained current authorized manning, it was acceptable.

Assumptions

Four major assumptions were used in this research:

1. Sample size calculations for work sampling followed a normal distribution.
2. All statistical assumptions for regression analysis were sufficiently satisfied.
3. The various taskings of work units could be grouped into categories and categories are independent and mutually exclusive.
4. Current levels of authorizations with MAJCOMS are at least minimally satisfactory but not necessarily ideally sufficient.

A glossary of technical abbreviations and terms can be found in Appendix A.

II. Background on Manpower Planning Concepts and Techniques with Specific Application to the Air Force

Manpower planning represents just a small fraction of the body of knowledge called management. Its concepts are closely related to those of management and its techniques range from intuition to complex statistics. Manpower planning concepts and techniques have direct application to any environment -- including the Air Force. The Air Force has developed a complex system to apply a portion of the overall contents and techniques. An examination of the literature describing these concepts and techniques will allow an appreciation of the approach proposed to solve the problem.

General Concepts

> Manpower planning and accurate forecasting are crucial to the viability of many forms of dynamic and complex social and economic environment. The penalty for inaccuracy is reduced efficiency, missed opportunities, and increased overtime if the forecast is short, and costly excess staffing if the forecast is long [12:32].

An underlying theme in this review is forecasting and planning. A forecast is a projection or estimate of the future. It is a premise for planning and are an integral part of the planning process, but are not plans (17:93). A forecast tells "what" while a plan tells "how." A forecast should be credible, significant, cost-effective and useful.

A forecast is credible if methodology and data used in developing it are valid, while it is significant if its results are other than intuitively obvious. A forecast is not of much use if it is too expensive to obtain in relation to benefits (14).

Harrison (17) describes managerial planning as being composed of strategic and tactical planning. Tactical planning deals with short-run goals and is specific. Strategic planning is broader and applicable to the long range; it is central to the future of the organization as it establishes organizational objectives. Lack of it indicates a deficiency in the organization (17). Among the subjects of planning is the human element (17). This human element can be thought of as manpower, and manpower requirements depend ultimately on strategic planning (39). Without objectives established by strategic planning, there would be no information upon which to base manpower determinations. A basis for manpower planning is data obtained from good, useful forecasts.

Planning for the human element can take on numerous forms for both the long and short run. It is not necessarily restricted to the simple cases such as determining staffing needs for an increase in production caused by a momentary demand increase. Also, it is not directly tied to the increase in manning needed for the addition of a new product line. This type of planning cuts across these forms of planning. Of the various forms of manpower planning, workforce planning (determining the number and kinds of workers needed to fulfill production requirements) is critical (5).

Supply and demand of human resources are integral to manpower forecasting and planning. Demand refers to the organization's requirement for people; supply involves the appropriate number of required people being available to meet the demand. The supply and demand factors are both internal and external to the organization. That is, staffing pressures and manning supply may come solely from within the organization, outside the organization, or a combination of both (5). Therefore, manpower planning and requirements determinations can be thought of in terms of a supply function and a demand function.

The various forms of manpower planning are influenced by the supply and demand of human resources. Manpower planning is a result of forecasts made that support the attainment of objectives specified in the strategic plan. The concepts of forecasting and planning are crucial to manpower planning and are central to the establishment of quantifiable expressions, such as models, descriptors, and standards of and for manning.

Models, Descriptors, and Standards

In general terms, a model is merely a representation of something else or a representation of reality (41). Manpower models are tools for organizing, understanding, and using data in decision making relative to inventory (supply) and requirements (demand) of human resources (28). A manpower model can also be described in its narrowest sense as a mathematical equation that expresses the manpower required in terms of a specific workload (33:9-2). Hence, manpower modeling is descriptive of the real requirements for manpower. In

their broadest sense, the models are intuitive algorithms; they become more complex when statistical methods are applied and evolve into complex standards when fully developed.

Models have been classified according to their use within an organization and the types of techniques that are employed. Regardless of classification and techniques, the same model can be used for determining supply and demand depending on how it is initially defined.

Four types of models exist: forecasting, organizational change, optimization, and integration. Forecasts predict the future within a given environment; organizational change models examine the past and forecast the future, noting and predicting changes; the optimal model describes the best of alternatives or situations. These models are synthesized into another model called the integration model (41). These classifications are further subdivided into techniques employed with models of the same classification often using varying techniques. The specific techniques are subjective and statistical. Subjective techniques are based on intuition, experience, estimation, and opinion. Statistical techniques can be based on either trends or on the relationship of organizational requirements to the environment (39).

Specific Models -- Techniques in Manpower Planning

Various models are available to quantify manpower, both in forms of supply and demand. The selection and use of a model depends on many factors, such as data type and availability, organizational desires, and capabilities. The results of models vary with the techniques employed and, as has been discussed, can be categorized (41). The following is a descriptive compilation of manpower models by categories:

Forecasting Model, Subjective:

Judgmental: Intuition and estimation based on management opinion. Technique implies that managers are aware of future development and changes in workload, so that they can estimate manpower (39).

Delphi: Involves repeated interactions of subjective, written estimates by managers obtained by questionnaire and administered and collected anonymously. When information has been collected, it is summarized and distributed to participants for analysis of the reasoning behind all individual estimates. The cycle is repeated until an agreement is reached. Keys to this techniques are exact problem definition and questioning and feedback (41).

Staffing: Developed from surveys and historical records of desired manpower strengths and distributors based on a level of activity. Primarily a service organization model (5).

Ratio Analysis: Projections based on trends of the ratio of indirect personnel to direct personnel (14).

Correlation Analysis: Relates business indicators to direct labor staffing levels by historical trend data. Subjective interpretations of the future (14).

Forecasting Model, Statistical:

Job Analysis: Projects tasks to be performed to accomplish objectives and assigns workloads based on standard times to accomplish tasks. This determines required manpower (41).

Organizational Change Model, Statistical:

Markov Analysis: Uses a probabilistic framework to determine movement within jobs. This movement can be caused by promotion,

retirement, or resignation. The probability of movement is used to predict the need and extent of staffing (41).

Renewal Approach: Considers replacement potential external to the organization, a version of Markov Analysis (41).

Regression Analysis. Defines staffing needs in terms of relationships between variables and workloads. The variables assume the role of indicators or descriptors. It assumes that a relationship exists and shall continue to exist (5).

Optimization Model, Subjective:

Goal Programming: Relates needs to organizational objectives and is a refinement of linear programming techniques. It tests manpower goals alternatives by examining the discrepancies between targets and results (41).

Optimization Model, Statistical:

Assignment Model: Determines optimal staffing under a set of mathematically expressed constraints. It allocates workload demand among work centers so that resources are best utilized (4).

Integration Model:

Simulation: Using statistical techniques, a computer model is developed for an organization under change. Requirements are determined by flows through the system (41).

The choice among model types depends on organizational emphasis and desires. Subjective models are good since management is involved in the process, and since the models used are not complex; it is, however, limited in its ability to handle large scale decisions where a

statistical technique would best be used. Ideally, a combination of various methods could be employed. An example of this would be the application of regression analysis where expected values of explanatory variables are obtained by collecting management opinion (39). Other examples include the Resource Allocation and Control Technique -- a linear programming technique that compares a work center manpower workload to manhours, skills, costs, and output to determine staffing levels (4). A combination of simulation and linear equations can be found employed in a model based on the Graphical Evaluation and Review Technique (2). Applications of various techniques are appropriate.

No general method for manpower planning applies to all organizations (39). There are, however, some items that are common to many manpower planning processes:

Estimate Requirements

Obtain Management Opinions

Forecast Levels of Activity

Compare Previous Forecasts

Translate Forecast Levels into Workloads

Make Adjustments for Overhead and Productivity

Translate Workload Factors into Requirements (4; 39)

Even though great progress in manpower planning has been made over the years, its general acceptance throughout industry is not as great as expected. Manpower planning appears to be an area of human resources planning that has not reached fruition (29). Military organizations have generally been more sophisticated about manpower planning than civilian industry (4).

Manpower Planning Concepts in the Air Force

Manpower planning in the Air Force provides inputs to the FYDP and PPBS -- the Department of Defense's equivalent of strategic and tactical planning. Inputs are in the form of manpower required to maintain the force. Outputs from these plans are also obtained as manpower requirements for new programs or weapons systems. Manpower levels contained in these documents are those authorized and approved for distribution; the levels support the programs contained in the FYDP (37).

To determine general manpower requirements at work center level, the Air Force has developed a Management Engineering Program. The control of this program is placed under the Air Force Management Engineering Agency. This agency has many detachments, called teams, located throughout the Air Force. The Management Engineering Team (MET), located at a major command (MAJCOM) level, is called a command MET and assists a MAJCOM in applying its manpower program. Functional METs are detachments that, among other things, are responsible for developing and maintaining manpower standards for work centers grouped by function (33). Manpower standards and guides are the tools used to determine, by application, required levels of manpower (37). These techniques are merely components of the manpower planning techniques that have already been examined. The basic techniques are the same except that they are much more defined and vary in method of application.

Manpower Planning Techniques in the Air Force

Manpower planning techniques employed by the Air Force deal with internal demand planning. That is, the techniques attempt to identify manpower required (demanded) to perform a function. Techniques in use can be identified as forecasting, organizational change, and optimal models of manpower planning using statistical analyses. These techniques are in use by Air Force manpower planners:

Ratio Analysis: Applicable to a single location, site, or work center unit. Times are developed for use in an equation. Manpower is expressed in the form of time to do a unit of work. It also applies to small population samples.

Simulation: Used solely to determine manning requirements for aerospace vehicle maintenance system; a mathematical model that determines system behavior and manning influence based on varying inputs.

Regression Analysis: Used primarily and is appropriate for multiple locations. It employs a mathematical equation that predicts manhours in terms of workload factors (33:9-5).

These techniques are highly similar to those previously presented and serve to demonstrate that Air Force techniques are merely adaptations of general concepts. What is unique about these techniques is their application. They are applied in a well-defined and structured manner.

Air Force Regulation 25-5 series provides a framework for adopting manpower concepts and gives detailed explanations on how to do so. Essentially, the application process framework involves these main

areas: feasibility study, study planning, and implementation (see Figure 1). Study planning is further broken down into measurement design, work measurement, and model selection phases. These are the general steps used in applying the manpower planning process.

* Feasibility
* Study Planning
  ** Measurement Design
  ** Work Measurement
  ** Model Selection
* Implementation

Figure 1. Manpower Study Framework

Feasibility Phase. The feasibility phase involves a decision making process and is the basis for standards development. In this phase, the area to be studied is analyzed on a macro scale and determinations are made regarding the basic complexity of the study. The reason for the study is to evaluate the need for a standard, to determine appropriateness of standards development, and to scope the function under study to get a feeling for its functions and requirements. Information gathered and decisions made in this phase form the basis for future study actions. Organizational structure is analyzed and general requirements are roughly defined by reviewing regulatory requirements and functional mission statements and administering

questionnaires. Specific functional requirements of the area under study are outlined to determine its taskings for the development of a work center description and workload factor(s). Units of measure of work are analyzed as possible descriptors of workload (i.e., workload factors). Job complexity, scope, and standardization, as well as organizational size and stability, are observed for impact. These measures combine with identified workload factors to link measures to specific categories of work represented in the work center description. Any possible link that can be classified as collectible and relatable is identified for potential future use. The concept of collectibility refers to the ease of which the link represents the work performed; that is, does the factor accurately describe and measure the work. This phase does focus on operational efficiency and the degree to which the function is standardized according to regulatory requirements (33:3-1).

Study Plan Phase. The study plan phase occurs when specifics are defined and analyzed. In this phase, actual study goals and requirements are determined, responsibilities defined, and the type of statistical study to be performed is determined. A Type I analysis uses engineered elemental times such as Methods Time Measurement and work sampling while a Type II analysis deals with these methods as well as operational audits. Type III analysis involves historical data, minimum manning, and staffing pattern techniques. Types I and II are described as measured approaches; Type III is considered non-measured. This is due to the degree of sophistication of the techniques used (33).

Measurement Design. Under measurement design, a specific work center description is derived from the feasibility phase results. The description breaks work into elemental categories, and the categories are used for work measurement. To insure that all tasked work is measured is the purpose of the work center description. A statement of conditions, which identifies and describes conditions under which work is performed, is also developed. This statement identifies extraneous factors that impact on work requirements or performance. Additionally, specific workload factors are determined for measurement. Areas that are not applicable across functions analyzed are identified as additives, exclusions, or deviations and merit further study. The general approach to measurement design is to determine study locations, work center descriptions (WCD), statements of condition (SOC), workload factors (WLF), and particular study techniques; from there, the work measurement phase evolves (29:7-1).

Work Measurement, Model Selection, and Implementation. Data collection methods are based upon the type of technique chosen in the measurement design. It is in this area that the design is implemented, assumptions validated, and data obtained for model selection. Data is analyzed by comparison to frequencies and applied to the statistical techniques previously discussed. Rough analyses are made by graphing unit times, task frequency counts, ratios of direct and indirect manhours and the like. A quantified expression, equation, or model is developed that describes manpower in terms of workload factors. Ultimately the model selected must satisfy statistical, logical, realistic, and economic constraints. Statistical constraints relate

to those that are applicable to the specific technique chosen; collectibility and relatability involve logical constraints. Realistic criteria are met when determined manhours increase over the range of workload factors, while economy is demonstrated by increases in determined manhours as workload factors increase. All that remains is to implement the standard at the work center level, thereby determining the manpower requirements for those functions. The resultant standard can be classified as one applicable to a single or multiple location (33).

Additional Considerations. As there is no general method for manpower planning for all organizations, methods must be specifically developed or common elements used. The particular method presented here is the method used in Air Force manpower planning and standards development.

Specific steps involved in determining the composition of the application process have not been discussed. A review of how to determine a WCD, SOC, WLF, as well as statistical, realistic, and economic criterion will be discussed.

A WCD can be thought of as a listing of work for which a function is responsible. This listing breaks work down into grouped categories to measure required manhours. It is the key to developing accurate workload factors. A WCD is determined by analyzing overall work requirements and logically and subjectively breaking them down into categories based on a classification system. The system stresses categorization by work flow and common characteristics such as methods or procedures. It defines direct and indirect work as major

categories. Direct work describes all tasks that represent a unit of work for the function. Indirect work includes all time when an individual is not available for work due to leave, illness, or military or organization-related commitments (34:17-1).

An SOC describes impacts of work conditions to the work performed. It functions as a complement to the WCD and results appear through the standard and the WLF. The SOC considers climatic, layout, and automated conditions. Identified conditions are related to appropriate tasks by the use of a SOC matrix. It is from this matrix that impacts and limitations can be determined (34:19-1).

Four functions are used to determine workload factors. Determined first are taskings specified in directives that state work requirements. Inputs into the functional area from these taskings are obtained next and related to actual work performed. The work performed by category is directly related to outputs, that is, tangible work produced. Relationship diagrams are established to show the flow of work from input to task to output. The relationships establish the basis for a workload impact matrix that relates factors and categories of work. From this, the more times a factor appears as a function of a task, the better descriptor it is of the task (e.g., number of vouchers processed in an accounting system). As discussed, WLFs must be collectible and relatable, but they must also be mutually exclusive, understandable, auditable, and collectively exhaustive of all taskings (34).

Standards allow for personal time, fatigue, and delay. An allowance is represented as a percentage of time that the worker is unproductive due to circumstances beyond his control; its concept is

well based in classical industrial engineering techniques. Approximately 15 percent of task time is an allowance (34:27-1). This equation shows the time, in minutes, permitted for allowances per individual:

$$\frac{480 \text{ minutes/workday}}{480 \text{ minutes/workday} - (P \times 480 \text{ minutes/workday})}$$

where P represents an appropriate allowance percentage

Regulatory requirements specify statistical, realistic, and economic criteria. These criteria are shown in Table I (33). Criteria are used in determining the suitability of the developed model to accurately describe manpower requirements. The criteria are based on statistical techniques of variance and regression analysis which have yet to be discussed and are presented here to provided a complete discussion of manpower planning standards and techniques as applied in the Air Force.

Table I

Modeling Criteria

Model	Realistic	Economic	Statistical
			Type I
			$R^2 > .75$
$\mu = b_0+b_1x_1+b_2x_2 \ldots$	$b_o > 0$	when realistic	$F > F_{.05,V_1,V_2}$
			Type II
			$R^2 > .50$
			$F > F_{.1,V_1,V_2}$

Summary

A review of the literature on manpower planning shows that planning manpower requirements are necessary for organizational viability and efficiency. Planning the human element has been directly tied to overall organizational planning. Additionally, the supply and demand of people must be considered when planning. The many and varied techniques of manpower planning apply to many different types of organizations. Which method to apply varies with organizational factors, while there is no standard method to apply the techniques.

One organization that applies manpower planning techniques and has a specific method to apply them is the Air Force. The Air Force uses regression analysis as its main planning requirements determinant. Manpower planning in the Air Force has been tied to the PPBS and the FYDP; it is linked with long-range planning. The techniques in use are merely a subset of the overall body of knowledge known as manpower planning techniques. They have both evolved in a similar fashion -- ranging from intuitive estimates to time standards. Manpower planning is accomplished by standards development using a defined procedure that seeks to define manpower requirements in terms of workloads. Once work functions and influencing factors have been defined and analyzed, the data obtained is used to produce a quantifiable expression -- a model or an equation -- to express manpower requirements. Of the framework presented, the heart is the study phase where design, measurement, and selection components are involved. These three components combine to represent the methodology of the problem.

III. Design Background and Specific Methodology

Background

A specific set of procedures used to develop a generic manpower standard for MAJCOM Engineering and Services organizations is presented. The method draws upon concepts and techniques already discussed; it features the elements of pilot study, work sampling, and regression analysis. In order to appreciate the selection and application of these techniques, it is necessary to understand their framework and general tenets.

Barnes (1) proposes a general problem solving framework that is appropriate for a standards development process which is akin to the various phases described in Air Force Standards development literature. His proposition includes defining and analyzing the problem, listing possible solutions, evaluating alternative solutions, and ultimately recommending -- all closely related to the feasibility, study, and implementation phases (1).

Before applying this structure, a pilot study can be performed as an exploratory tool to determine the ultimate approach to the problem (13:88). Central to the investigation are the methods analysis, work measurement, units definition, and performance measurement steps. These four steps seek to define tasks and measure performance levels through productivity over a period of time (19).

An approach in applying these problem solving elements involves relating tasks to the amount of time required to perform them. Time study, predetermined motion times, standard data, or work sampling techniques are used to establish a basis for required times. When developing work times, there is no interest in improving work methods but rather to describe the time needed for present taskings. Interest can be in elemental times of specific operations or of general classification of tasks for an entire job. Using the latter technique, the object is to determine the time spent to accomplish a like group of tasks over a given period. A grouped task considers the individual responsibilities of each function as an operation without regard to the sequences required to perform the operation (1). Regardless of chosen methods, measures must be reasonably representative of the tasks, relatively consistent, quantifiable through units of output, and have a volume sufficient to warrant measurement (7). This research used work sampling techniques to gather data and regression analysis to transform that data into appropriate manpower standards.

Work Sampling

The technique of work sampling was chosen to determine the amount of time spent by organizational elements performing various categories of jobs at the MAJCOMS to be studied. Work sampling is a technique that relies on statistical sample procedures that seeks to determine the proportions of time spent by an activity, man, or machine in each component of total work activity (25). Its application can be likened to taking a snapshot of the job; that is, there is a gap between sample

readings and occurrences (20). It is best used when time between task repetition (cycle time) is long, people work as a group, or when time study is considered inappropriate. It requires standard methods of job accomplishment based on written instruction. It can measure the production delay caused through man-machine interfaces, measure a worker task performance index, or establish time standards (1).

Basis. The technique is based on the laws of probability and the central limit theorem. It assumes that if an average sample from a population is sufficiently large, the sample will be representative of the characteristics of the population (1). By employing the central limit theorem, normality of the sample distribution is implied. The sample is random, hence reducing the chance of bias (1). What this means for practical application is that after repeated samples or observations, the average percentage of time spent performing the various groupings of tasks is descriptive of the total job and the distribution of the percentages is normal. It also permits the determination of a statistically acceptable sample size by approximating a binomial distribution. (Individual observations can be thought of as binomial -- either productive work was observed or it was not.) (20) Work sampling techniques are related to time standards by developing unit times required to perform each grouping of tasks for a total job. The sum of unit times represents the total time required to perform all job task requirements. The following equation is appropriate (1):

$$\text{Task Unit Time} = \frac{\text{Total Time Available In Study} \times \text{Percentage of Observations Spent Performing Specific Task}}{\text{Number of Units of Work Produced by Specific Task}} + \text{Allowances}$$

Procedure. A work sampling study is developed and implemented through specific procedures:

1. Divide the work tasks of the function under study into categories. Group the tasks according to specific operations and not by each step of each operation.

2. Determine the degree of accuracy and confidence desired and the percentage that each task comprises of the total function (These items relate to the amount of error that is acceptable in the results.)

3. Determine the number of observations required by applying the following formula:

$$n = \frac{(Z)^2 \, p \, (1-p)}{A^2}$$

where

n = sample size

A = absolute accuracy

Z = normal Z value appropriate for number of acceptable standard deviations corresponding to the desired confidence levels

p = mean percentage of task occurrence

4. Determine the time period, days, weeks, or months, to conduct the study.

5. Determine the sampling plan for observations by determining when observations will be taken by random sampling throughout the observation period. Also determine the condition under which sampling should occur so that bias will be reduced. Bias can stem from observer classification to participant expectancy (1; 20).

Research on the numbers of observations and study span required for work sampling techniques revealed that "at best, the decision is an educated guess" (22). There is no general consensus among the experts as to absolute sample sizes (in total or per individual) nor duration of a study; general rules of thumb do, however, exist. The rules of thumb are largely subjective and, thereby, permit a wide range of methodology designs so long as some validation is possible.

The value obtained from statistical calculations of sample size must be interpreted in view of the goal of a study. If calculations revealed that 743 observations were required and the study goal was to determine the functions performed by all service managers, 743 observations would be required, in total, from the entire group of managers. If the goal were to determine the functions of a single manager, 743 observations would be required of that manager (22).

Study span considerations dictate the representativeness of the activity during the period under study such that the constraint of seasonal/cyclic effects will not bias results. The cycle must be long enough to minimize bias. The sample should cover two or more weekly/monthly/quarterly cycles.

Given these considerations, experts contend that thousands of samples are required to establish a time standard using work sampling

techniques. With a 1 to 2 percent accuracy level, at most 10,000 samples would be required. A lesser number is more often sufficient for a lesser degree of accuracy. Barnes (1) states that roughly 4,000 observations are sufficient. If "p" is not small, a good sample estimate is 1,000 (1; 22).

Work sampling techniques have great appeal and application as they are relatively simple to use and can be used when other methods are not possible. Reliability and validity considerations are represented in the sample size used. Additionally, observation periods can be extended thereby eliminating cyclic variations. Errors can creep into sampling plans due to incorrect classifications of observations as changes in work habits in response to observations (1).

Diary Studies

Office work, especially that of managers at various levels, has been characterized in management literature as a massive amount of work performed at a quick pace. This necessitates work that is current in issue and requires brief, varied, and fragmented periods of work. There is interest in the general nature of work because if work distributions and management processes are known, then an insight is gained into how to handle the work environment (23).

There have been a few studies of the nature of work in recent years; the most famous of these studies was one by Rosemary Stewart (1967) and another by Henry Mintzberg (1973). Among other things, these studies described the distribution of work -- not from a job category standpoint but from a content and contact perspective -- that

is, they classified work into the type of things done and the environment in which they were performed.

These researchers used a diary method to obtain their data. The diary method is essentially work sampling only observations of work are made by the individual being studied and not by an observer. It employs the use of a form that categorizes factors it desires to measure and requires the individual(s) under study to merely check the most appropriate grouping at a specified time that describes the type of work being done and its environment. In essence, the users of the form are the individuals under study. This method has been found to be efficient for collecting data from a large number of people.

In Mintzberg's study of five executives, he discovered that a typical day consisted of seven work sessions, thirty-six items of correspondence, five phone calls, eight meetings, and one tour. A breakdown in percentages of time spent doing such things and with whom as reported in Stewart's and Mintzberg's studies can be found in Table II. It is important to be aware of these studies, their methodologies, and their findings, as all can be related to the distribution of work by job category (23).

Regression Analysis

Regression analysis techniques have been chosen to correlate units of measure for various work sampling categories of tasks in the development of a time standard for the functional area under study. "Regression analysis is a technique used to study the relationship between measurable variables" (8). It seeks to investigate

Table II

Results of Work Content and Contact Distribution

Content	Percentage of Time: Small Organization	Large Organization
Desk Work	35	22
Telephoning	17	6
Meeting	36	69
Touring	12	3

Contact		Stewart Study	
Subordinate	56	25	48
Peer	2	8	11
Boss	0	8	12
Alone	6	34	8
Other Employee	30	12	17
Client	6	10	3

relationship strengths (predictions) or the nature of relationships (explanatory) (21). It determines if one variable is affected by changing values of another variable and tests relationships by fitting a line through data points to represent and estimate relationships (22). "Regression analysis techniques are used as tools to evaluate a stated mathematical association between variables" (34:33-11). The examination of relationships within the population from the sample data is the result of an inferential process that will determine which variables are closely related to other variables. The establishment of linear dependence of one variable on another variable represents the descriptive process (26). Among its various applications, regression analysis can be applied to establishing time standards and manpower determinations. "Regression analysis is the method of finding the mathematical equation that best predicts man-hours in terms of one or more workload factors" (33:9-1).

Assumptions. Regression analysis techniques require that certain assumptions be accepted in order to use the techniques. The assumptions include:

1. Linear, straight line, relationship between independent (predictor) variables and dependent (response) variable.
2. Residual values (the difference between observed and predicted values) are normally and independently distributed with a mean of 0 and a standard deviation of 1.
3. Interval level data (22).

Basis. The basis for regression is the development of a line, or equation, that attempts to represent and estimate variable

relationships through sample data points. This line can be represented by the following general linear model:

$$Y = b_0 + b_1x_1 + b_2x_2 + \ldots + \epsilon$$

Least Squares Approach. If the line is to be an accurate representation of reality, the distance between the descriptive line and the sample data points needs to be as small as possible. The procedure used to minimize this distance is the least squares estimate. The goal is to find coefficients (b values) for the equation of the line such that the sum of the squared differences between the observed value of the response variable (y_i) and its corresponding, predicted value ($\hat{y}$) is minimized. Figure 2 represents the least square criteria (22).

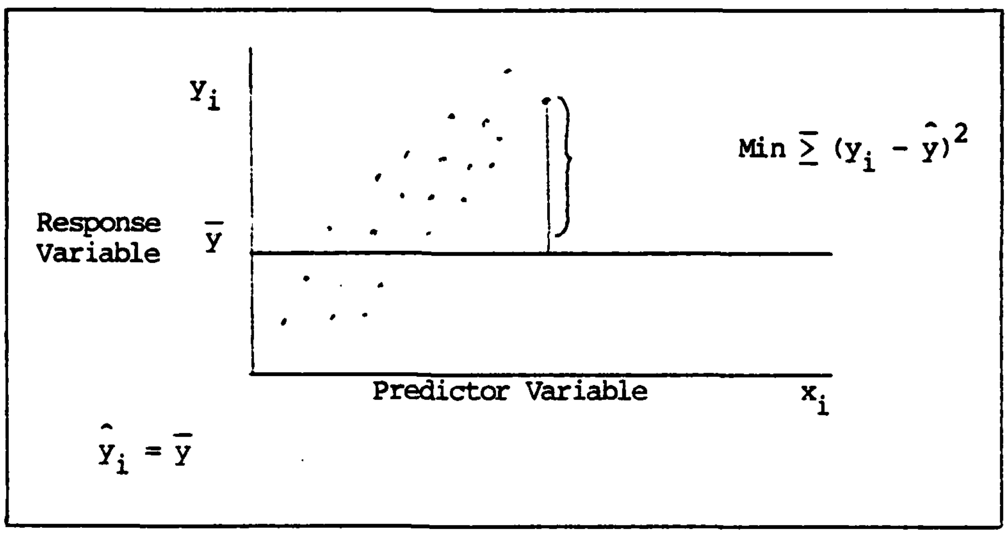


Figure 2. Example of Least Squares Fit

The difference between actual and predicted values represents an error and is what the least squares estimate minimizes. From this, appropriate equation coefficients can be determined by taking the partial derivatives, with respect to each desired factor, when the least square distance is assumed to be zero. The resulting equations can be solved simultaneously to yield coefficients (21; 22).

<u>Partitioning</u>. The line that is most representative of the variable relationship results in the smallest sum of squared difference between it and the data points. Ideally, any difference will be zero, but this is not always the case (21; 22). When the difference is not zero, there is a failure of the model (linear equation) to provide for an exact fit; thus, there is variability or error (8). The variability (error) can be partitioned into components explained by the model and components unexplained. The concept of partitioning is crucial to the development of model usefulness criteria; it is represented in Figure 3.

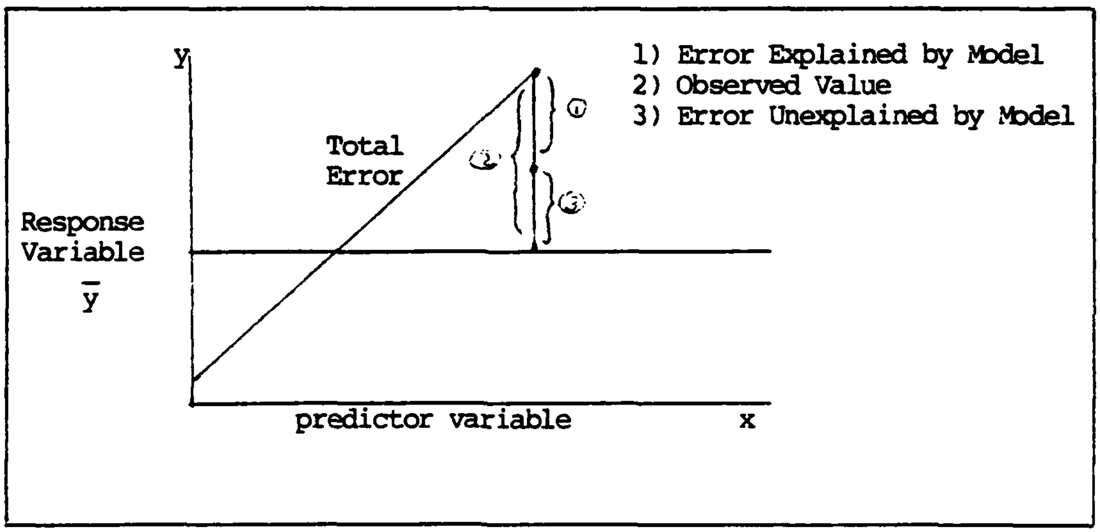


Figure 3. Presentation of Error Partitioning

The concept of least squares estimate strives to keep the sum of the squares of the difference between the line and the data points to a minimum. With partitioning, this equates to a minimization of the sum of the squares of the unexplained error in the model.

Linearity and Usefulness. A line can always be calculated to fit data regardless of the extent of resulting error. Care must be taken to insure that the data and the descriptive line are linked by a relationship minimizing error (8). Regression analysis assumes a linear model — a linear relationship between data and the dependent variable. Not all variables may define a truly linear relationship, thereby invalidating regression assumptions. In order to apply regression techniques, the linearity assumption must be validated. To do this, each individual predictor variable must be graphed against its associated response variable. If the result demonstrates a degree of linearity, then regression techniques can be used. If not linear, a transformation of terms to develop a linear relationship can be performed thus enabling the use of regression.

Having determined the appropriateness of the linearity assumption, a statistical test is performed to determine which terms, as variables, are useful in explaining a significant portion of error. The statistical test draws upon the concept of error partitioning and attempts to prove the following hypothesis:

$$H_o: \; b_j = 0$$

$$H_a: \; b_j \neq 0$$

where

b_j represents the previously calculated coefficients for the descriptive equation and is for all j from i to n.

The corresponding test statistic for usefulness is:

Reject H_o if:

$$\frac{MSb_j}{MSE} > f_{1,\ n-k-1,\ \alpha}$$

where

MSb_j represents the sum of the square of the difference of each predictive term divided by its corresponding degrees of freedom. This is the mean square of the error <u>explained</u> by the model

MSE represents the sum of the square of the difference of the error term divided by its degree of freedom. This is the mean square of the error <u>unexplained</u> by the model

n represents the number of data points in use and is a degree of freedom

K represents the number of variable terms and associated coefficients in the model

α represents the probability of making an incorrect decision.

If the test proves a rejection, the corresponding variable is truly descriptive of the relationship and is appropriate for the model. If not rejected, the opposite is true and the variable should not remain in the model. With minor modifications, these hypotheses and test statistics can apply to the single as well as the multiple regression case. This test statistic is performed for each prospective model variable. The model is then composed of solely descriptive, useful terms and, therefore, the model itself could be deemed useful. The usefulness of the entire model can be determined by applying the previous test statistic in much the same manner only substituting the total mean square explained by the model as opposed to the mean square explained by the model with a single variable (21; 22).

Descriptive Concepts. There are numerous indications that aid in describing and determining variable relationships:

1. The coefficient of determination is the ratio of the sum of the squares of the regression terms to the total sum of the squares. It measures the percentage of total variation explained by the model and is an index of the degree to which the model fits the data. The value, "r^2" can range from 0 to 1 with 1 representing the ideal (21; 22).

2. The square root of the coefficient of determination is the coefficient of correlation. This is a measure of how the predictor and response variables vary with each other. It represents or describes their relationships in terms of the degree of linearity. A value of zero represents no linear relationship while a value of ± 1 describes a distinct positive or negative linear relationship. The concept not only pertains to the predictor and response variable but can also measure relationships among predictor variables. It is used primarily in simple, one variable cases or with only one variable at a time. The expression assumes the sign of its corresponding model coefficient. The multiple correlation coefficient, or multiple r, pertains to the relationship of the dependent, response variable with the whole model. The multiple r can assume a value between 0 and 1 (21; 22).

3. The mean square error has already been defined. The model attempts to minimize this value. The lower the value, the better the developed model fits the data thereby being more representative and descriptive.

4. Residual values must be normally and independently distributed to not violate regression assumptions. Residual values represent the error unexplained by the model and are useful in determining other factors that could impact the model. If more than roughly 40 percent lie outside two standard deviations, normality assumptions are not valid (9; 22).

5. Multicollinearity represents a condition where one or more independent (predictor) variables are highly correlated with another predictor variable; there is a near linear dependency. This condition can be recognized by calculating the correlation coefficient defined above and noting the resultant value. An "r" value of .3 or higher is a good indication of multicollinearity. The particular difficulty lies not with the whole model but with the individual variables. Multi-correlated variables do not contribute toward model development and serve only to create prediction difficulties so they should be eliminated. To eliminate, conduct "k" simple regressions to determine the variable(s) that best explain error but minimize interrelationships. This procedure should be repeated using increasingly complex number of variables until the best model is obtained (9; 22).

6. A correlation between residual values is an indication of autocorrelation. This difficulty causes false significance and can be noticed by examining residual values for any possible pattern. If a pattern exists other than a random and symmetric distribution about the residual mean value, there is a possibility of autocorrelation. This means that assumptions used in formulating the model are not valid. Ways to check include a visual examination of residual values or by

using the Durbin-Watson test. A value of approximately 2 on this test signifies little or no autocorrelation (9). Recheck formulations, add more survey time, or add additional observations or data points in order to correct the difficulty.

<u>Confidence Interval</u>. A prediction interval that represents the confidence limits for a single future observation can be calculated from a statistically derived equation. This limit serves to describe the range of particular response variable will take based on the developed model response. By a similar means, a confidence interval can be developed for the location of the regression model equation through its data. The prediction interval is more useful in determining the validity of the developed model because it produces a range of potential responses that can be compared to an established acceptable range. The interval can be found by:

$$\hat{y}_i \pm t_{n-2,\ \alpha/2} \sqrt{MSE} \sqrt{1+\frac{1}{n} + \frac{(X - \overline{X})^2}{\sum_{i=1}^{n} (X_i - \overline{X})^2}}$$

where

- $\hat{y}_i$ is a data point obtained from a regression model
- n is the number of cases
- α is the probability of making an incorrect decision
- MSE is the Mean Square Error
- X_i is the X value corresponding to Y_i
- X is the original data point(s)
- $\overline{X}$ is the average of the original data points (21;22)

Types of Regression. Given the complexity and extent of calculations required to perform regression, analysis can rapidly get out of hand. There are many types of statistical packages that an be used to enable complex analyses. These packages allow the user to easily explore the various types of available regression methods without repetition and tedious calculations. Three methods of regression can be performed:

1. Forward: This method begins by determining the constant term (b_o) for the model equation. Each potential predictor variable (x_i) is tested for model inclusion; the variable that reduces error the most is added. The process continues until all available variables are in the model, iterations reach a well defined stopping point, or the remaining variables do not reduce error by a statistically significant amount.

2. Backward: Procedures in this model are the reverse of those used under Forward regression. The model begins with all predictor variables contained and removes one-by-one those that reduce error the least and are not statistically significant. This method proceeds until directed to stop by a user function or until all included variables are statistically significant.

3. Stepwise: This method is a combination of Forward and Backward regressions. It calculates a partial correlation between two variables (the dependent and independent) and uses it for inclusion criteria. The method begins with the model composed solely of its constant value and considers variables for addition based on the highest partial correlation. After a variable has entered, the model is examined for variable exclusion. The process repeats itself until the most

statistically significant model has been developed or until stopping criteria is reached (21).

Model Determinant Factors. When examining the product of statistical packages, the following indicators should be used to determine the most descriptive model:

1. Increasing "r^2": Variables that contribute to increasing "r^2" are candidates for model inclusion. As this represents the degree to which the model fits the data, it is sufficiently descriptive of reality and measures the amount of variation explained.

2. Decreasing Mean Square Error: Mean Square Error deals with the error unexplained by the model; the goal is to reduce the factor. With decreasing Mean Square Error, the goal is being achieved there by transferring variation to that explained by the model. Reality again is accurately represented.

3. Variable Significance: If the prospective incoming variable passes the usefulness test statistic, it should be included in the model. This means that the variable is useful in describing a relationship and represents a decreasing Mean Square Error.

4. Coefficient Stability: If regression coefficients are stable from succeeding step to step, then the addition of another variable does not greatly alter the coefficients of the equation fitted to the data. This helps show a linear relationship among factors and respective data.

By applying these four concepts a model can be selected that best represents reality. There are no hard and fast rules regarding use

of these criteria. The best model results from a general consensus or agreement of all indicators.

Approach. A specific procedural approach is used for the application of this technique:

1. Sketch the relationship(s) of response and predictor variable(s) to test the appropriateness of linearity assumptions.

2. Determine the coefficients of determination and correlation. Analyze these factors as well as checking for multicollinearity.

3. Determine appropriate coefficients for the model being examined (i.e., simple or multiple regression).

4. Test the usefulness of each individual coefficient in describing the modeled relationship and reducing error. The usefulness of the entire model can also be examined using the same procedures.

5. Plot residual values, check for autocorrelation, and check for normality.

6. Infer relationships and select the most appropriate model using model determinant procedures.

Justification of Techniques

The techniques proposed to determine a generic manpower standard are appropriate for this problem. There is no one best way to measure work activity; it depends on the situation and the way the job lends itself to measurement (7). Work sampling is recommended where work is not repetitive and there are no standard units of work. This type of work is normally found in an office environment (43).

Little distinction has been made up to this point between simple and multiple regression. The concepts and techniques are the same, only multiple regression deals with several independent, predictor variables. Regression analysis is the foremost tool of statistical

analysis. It is used to examine relationships between a single variable and the other variables (18). Because this research attempts to define required manhours for various work centers in terms of workload factors, regression analysis techniques are appropriate.

Specific Methodology

Pilot Study. Akin to the feasibility phase of the development process, a pilot study was used to gain a macro-perspective of the difficulties experienced by MAJCOM Engineering and Services staffs and the applicability of the HQ AFRES study to these staffs. Each of the seven MAJCOMs meeting study criteria was asked to review and apply time standard methods extracted from the HQ AFRES study. One model for each of the directorates was selected for review. The staffs reviewed workload factors for appropriateness and applicability to their MAJCOM as well as compared the manpower levels presently authorized. The pilot study determined MAJCOMs, directorates, and branches should be studied based on their responses of appropriateness and comments. See Appendix B for an example of the study instrument.

Table III represents the results of manpower level comparisons between those currently authorized and those proposed by the HQ AFRES branch level models across commands surveyed. The comparison used the current authorization as a baseline guide and assumed that this level represented a satisfactory level of manning. This assumption can be made in that the basics of each function are being performed by current manning. If required functions were not being manually performed (note a distinction between satisfactorily performed), trouble will result thereby forcing a manager to obtain additional personnel.

Table III

Comparative Results of Pilot Study

Branch*	AFLC		SAC		MAC		TAC		AFSC		Evaluation
	Cur	Proj	Cur	Proj	Cur	Proj	Cur	Proj	Cur	Proj	
Programs	5	8	14	14	6	10	10	18	7	2.6	Mainly Excess
Real Estate	2.16	1.35	5	4	2	2	5	3	1	1.3	
Construction	8	2	7	5	7	6	8	5	5	2.3	Shortfall
Maintenance Management	7	4	19	7	12	14	9	9	4	4.6	Minor Mixed
Fire Protection	3	1.2	5	3	3	2	3	4	2	1.6	Minor Mixed
Housing and Services	6	.96	16	13	11	16	20	33	4	3.7	Major Mixed

* Figures exclude directorate chief and administrative support

An "excess" listed in the table means that the HQ AFRES proposed model permitted more manpower than currently authorized while a "shortfall" is the opposite. A "mixed" indication means that an excess existed in some command results while a shortfall was found in others. As the table shows, the Real Estate branch model accurately describes manpower levels across commands; this is also true to a lesser extent for the Maintenance Management and Fire Protection branches. This, for the meantime, ruled out study of these branches and their directorates. The Construction and Housing and Services areas were not so representative and, therefore, were candidates for further study.

A review of comments provided in the MAJCOM evaluation revealed, among other things, a strong dislike for workload factors used in the HQ AFRES study. Just because a HQ AFRES model projected a manpower level close to a MAJCOM's baseline figure does not mean that the projection is valid; it may have been mathematical luck. For example, the Maintenance Management standard is partially based on the number of tenant unit locations supported. The level of support provided by the MAJCOMs for tenant units is totally different between HQ AFRES and other commands. In most instances HQ AFRES tenant units have a Civil Engineering element attached and it performed the majority of work for a tenant location with coordination of the host unit. The situation is nearly reversed for active units. There the HQ AFRES model was in some cases satisfactory not because it was representative of workload but rather size differences between commands. This could invalidate models previously accepted as satisfactory. Anyhow, models never accepted as

satisfactory (i.e., Engineering and Construction) still are not satisfactory and were examined first.

The Engineering and Construction and Housing and Services Directorates were identified for this study and the Housing and Services Directorate was chosen. This Directorate was chosen because it represented the directorate with the largest difference between projected and baseline figures for each MAJCOM and projected figures across all MAJCOMs. The workload factor used was rather mission biased and not universally representative; this can be seen between the projected figures for AFLC and TAC. Additionally, given time constraints, this directorate represented the smallest number of baseline authorizations, thereby making it easier to study.

Three considerations were given to the selection of MAJCOMs for study: size, mission, and practicality factors. TAC represents a large operational command while AFLC represents a small support command with large bases. AFSC is a diverse support command. These commands were receptive to the study and all lie in a geographical proximity.

There were three options regarding how to survey with potentially many facets to each option. The first option was to approach each MAJCOM involved (after initial study support is obtained) and request that each individual under study be permitted to take his own observations. This option has a disadvantage in that the individual may falsify categories on work performed or just may never record observations. An alternate MAJCOM method was to request support from them in the form of a person detailed to work the project. This person needed to be someone who is of adequate intelligence and motivated.

In either case, training was required on what and how to do sampling as well as how to handle leave and TDY situations. Adequate training would be essential to the ultimate validity. MAJCOM representatives could have been able to offer alternatives to this approach.

Another method would be to request the support of a local MET office to lend a person to perform work sampling. This would have been ideal in that no training would be required other than a brief study orientation. Problems exist, however, in that the local MET office had nothing to gain by assisting and had already scheduled work.

The last alternative would be for the researcher to conduct all studies. This would be the best method but was totally impractical given time limitations. It was because of the limitation involved that it was deemed practical to have each individual under study perform sampling of his own work. This was the chosen alternative.

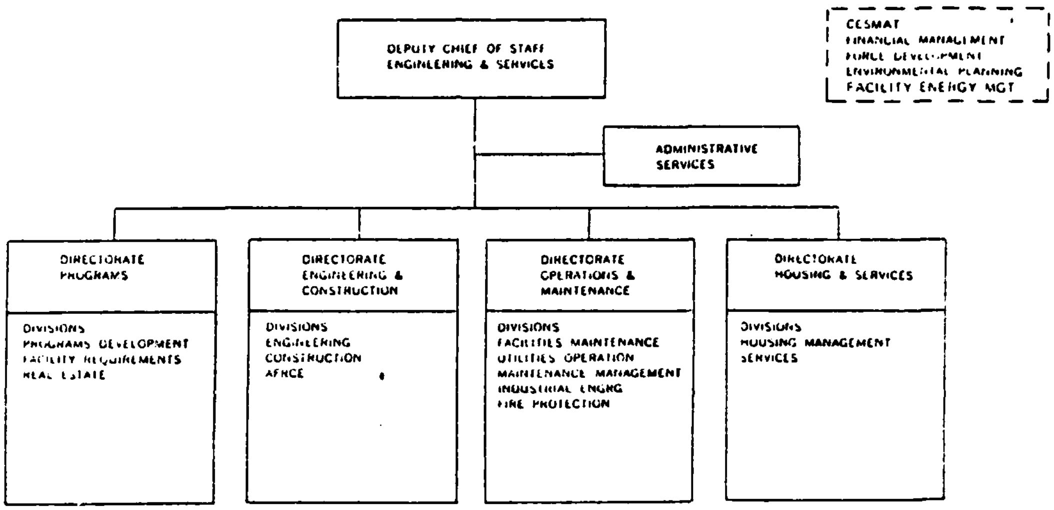
Work Sampling. Specific determinations regarding organizational structure, job categorization, workload identification, and sample planning represent methodology steps and can be compared to study planning. Here, the five specific steps of work sampling previously discussed were developed for application to the thesis problem.

AFR 26-2 and AFR 85-7 describe how MAJCOM staffs are to be organized. One of the requirements of work sampling is standardization of the function and tasks measured. In reality, no MAJCOM Engineering and Services organization is fashioned exactly after regulatory specifications. This appears to be an obstacle to analysis, but was realized that commands had the same basic functions, just aligned slightly differently. Therefore, what initially appeared to be an

obstacle was actually no obstacle. Figure 4 shows how a standard organization would appear while Table IV tabulates structural differences across commands. Appendix C demonstrates procedures used to select and group structural differences. It also shows how functions relate to a standard structure and how this report chose to analyze them as well as structural areas identified for additives. (An analysis of additive requirements was not done.)

The job responsibilities for each branch outlined in AFR 85-7 can be likened to general work center descriptions. For this analysis, they functioned as such. A comparison between these job requirements and those developed for HQ AFRES showed little difference. HQ AFRES descriptions were developed along a work flow line and were slightly command specific. That is, they trace the flow of work by describing each type of report processed including specific processing actions. AFR 85-7 taskings were more categorical as they merely state processes for example. Categorical work development is directly applicable to work sampling and was used. Some categories were added to the descriptions for the purposes of the study. To accommodate structural differences, the descriptions can be thought of as modular. That is, the same basic functions are performed but by a different organizational element. This should be remembered when sampling. Appendix D represents job categories for work sampling for each branch studied.

Workload factors function as the independent or predictor variables of the work-to-manhour relationship. They can be defined as the units of measure expressive of the manpower required to accomplish the responsibilities of a work center (33).



*Each of these may be established as a directorate/special staff office, as a division within a directorate, or as part of a division

Figure 4. Structure Chart

Table IV

Structural Differences Across Commands[1]

Function[2,3]	Command: TAC	AFSC	AFLC	MAC	SAC	SPACECOM
Programs						
Program Dev	x	x	x	x	x	x
Facilities Req	x	combined	combined	combined	x	separate functions
Real Estate	x				x	x
Engineering/Construction						
Engineering	x	x	x	x	x	x
Construction	x	x	x	x	x	x
Operations/Maintenance						
Facilities	x	x	combined w/maint	joint	x	combined w/programs
Utilities	x	x	x			x
Maintenance	x	-	combined	x	2 staffs	-
Industrial	-	-	-	-	x	-
Fire	x	x	x	x	x	under programs
Housing/Services						
Housing	2 staffs	x	x	x	x	combined
Services	x	x	x	x	x	

1. No data currently available from ATC.

2. An "X" indicates that a MAJCOM possesses a particular function. Only the four main directorates were considered for comparison and analysis.

3. Some commands title their functions differently than the standard, but their functions are basically the same.

Factor Determination. Potential workload factors for this study were determined subjectively in much the same manner as Air Force applications dictate. A work flow was not, however, developed because evaluation was done at a categorical level instead of a specific task level. Factors included in the HQ AFRES study were not always included; items from the pilot study were included. A list of potential workload factors used, by branch, is given in Appendix E.

An examination of taskings by category as specified in AFR 85-7 provided workload factors that were suitably descriptive of the various work categories. Additionally, MAJCOM responses to the pilot study provided factors that each MAJCOM felt were appropriate for each of the categories at the specific MAJCOMs. These two approaches were coupled with discussions with functional representatives of the Housing and Services Directorates at each MAJCOM studied. There was a general commonality of suggested workload factors. Factors that were descriptive and continually recommended were chosen as potential workload factors for this research.

Sample Plan. As discussed, the specific sampling plan was solely determined by the goal of the study. Modeling analysis was performed at the branch level but the ultimate goal was to develop an authorized manpower level for Housing and Services, the directorate under study. Therefore, it is appropriate that the required sample size calculated be applied at the directorate level instead of the branch level. This means that the calculated number is the total number of samples needed from the entire directorate and not the number required from each subunit (i.e., branch, section, or individual). The sample size was

distributed over each subunit so that each subunit is sampled and analyzed, but the total number of samples taken from each subunit aggregates to the required sample size calculated. Each MAJCOM was initially analyzed separately so the sample size determined is applied to each MAJCOM and not aggregated in total.

Chapter 2 presented a formula for determining the minimum number of samples required in a work sampling study to assure that observed results are representative of the actual situation according to desired confidence. Applying the formula results in:

$$\text{Required Minimum Sample Size} = \frac{(1.96)^2\,(.85)\,(1-.85)}{(.03)^2}$$

$$= 544$$

where

1.96 represents the Z value corresponding to confidence to the second standard deviation

.85 represents the percentage of time engaged in some form of productive activity less 15% allowances (1)

.03 represents the absolute accuracy of the sample (Air Force Specification for a Type I standard — the most statistically accurate)

This equates to a minimum 544 samples required from each of the Housing and Services Directorates of each of the MAJCOMs under study. A study span of two weeks (ten working days) was arbitrarily chosen. The number is appropriate in that the period is long enough to observe the entire working environment but short enough so as not to disturb it. Any chance of cyclic work requirements not being observed was greatly reduced as a second study of equal length was conducted during

a month and time of month different from the first study. Adequate study span and repetition helps insure representativeness.

Additional study parameters dependent upon the results above have yet to be discussed. The total number of observations which also impacts on the timing of randomness of the sample. One other factor was necessary in the frequency calculation and that is the number of people involved during the study span. This was defined as the number of people currently assigned to the Housing and Services Directorate of each studied MAJCOM with the exception of the directorate chief and administrative support. The manpower figures were provided by each MAJCOM. Following are the calculations used to determine observation frequencies; three separate calculations are shown because the number of assigned personnel varies by MAJCOM.

$$\text{TAC:} \quad \frac{544 \text{ observations}}{18 \text{ people}} \times \frac{1}{10 \text{ days}} = 4 \text{ observations/person/day}$$

$$\text{AFLC:} \quad \frac{544 \text{ observations}}{5 \text{ people}} \times \frac{1}{10 \text{ days}} = 12 \text{ observations/person/day}$$

$$\text{AFSC:} \quad \frac{544 \text{ observations}}{4 \text{ people}} \times \frac{1}{10 \text{ days}} = 14 \text{ observations/person/day}$$

These numbers were rounded to the highest whole number so as to capture the entire, required sample. The numbers equate to 720, 550, and 560 observations and total to 1,830 for one period and 3,660 for two periods. These numbers are in excess of the calculated 544 per MAJCOM, but it should be remembered that this figure is only a minimum.

Additional observations caused by the rounding error (or potential limitation) would only increase the accuracy. These numbers approximate those of the sample size heuristics previously mentioned. Results were not biased due to differing sample sizes because proportions were used.

Within these number of observations per timeframe, the observations were made at random intervals by using numbers generated from a random number table and taking into account lunch periods (when no observations should be made). There was a different set of random observation times for each day in the workweek; the set was repeated each week. By designing the study in this fashion, a day is considered a cycle and the observations within the cycle are random; twenty such cycles were used over the course of the study. Random observation times for each MAJCOM are given in Appendix F.

Sampling was conducted by each individual in the Housing and Services Directorate of each MAJCOM studied. Each individual recorded observations of himself according to the specified random times. He was given an instruction packet that explained the purpose of the research, the need for accurate, valid responses, and specific instructions on how to make and record observations. The instruction sheet also explained how to handle classification problems, who to contact to help resolve problems, and procedures on how to return the sampling instrument. The packet contained observation forms on which to record observations and a random observation time sheet to reference for observation times. The instruction packet constituted training for the observer. An example of the packet is provided in Appendix F.

Because of the differences in the numbers of observations and their times, separate packets were produced for each MAJCOM.

In order to make and record an observation, the observer must have his sheet of random times and observation form readily available. When a random time occurred, the observer placed a check in the box that represents the category of work he was performing at the time. Work categories were those specified in AFR 85-7 and shown in Appendix F. Additionally, each person would also place a check next to the condition that most accurately represents both what he was doing and with whom at the time of the observation. This procedure was then repeated for each observation throughout the study period. At the end of the study period, each observer gave his form to someone in the directorate designated to collect and return the forms to the researcher.

Before this method could be used, approval was obtained through the chain-of-command from the respective Deputy Chiefs of Staff (DCS) for Engineering and Services. Active support from the DCS' helped guarantee the accuracy and validity of the results. There is a problem of using this method of collection because it is easy to get biased results because of a lack of cooperation or inaccurate recording on the part of the observers. Konz (20) feels that people will eventually tire of behavior modification for the observations and will not be able to continually provide invalid responses so long as the observation period is sufficiently long.

Work sampling techniques were used to gather data required to develop a manpower time standard. Because sampling was done on a job category level as opposed to a task level within a category, the use

of the task unit time equation associated with procedures for time standards was not appropriate. It was for this reason that regression analysis was chosen as the method for standards determination.

Data Preparation. The raw data returned by each MAJCOM must be grouped and transformed for proper input into statistical analysis methods. The data was grouped for each MAJCOM by branch for each day of the survey. This equates to twenty data points for each command (ten days/sample period x two sample periods) with each day being treated as a single observation. (Each single observation was composed of the individual observations for each person in the branch.) Across commands, there was a total of sixty data points in the study for each branch; two branches were examined.

Not only was data grouped by day, it was also grouped by job category within each branch. An example would better illustrate the grouping methods. Suppose ten returned survey forms represent a complete response from a command for a day; each form has five job categories and four possible observations per day. The total number of observations for the day can be calculated by multiplying the number of forms by the number of observations permitted on each form; in this case, 10 x 4 = 40. For each job category, the number of observational checks made would be counted for each survey form. Each survey would now have five numbers representing the frequency of occurrence that each job category was observed throughout the day for each individual. (In this example, these numbers can range anywhere from zero to four.) Each number on each form for each respective category is added together to obtain the frequency of occurrence of each job category observed

throughout the day for the entire branch. (These numbers could range from zero to forty in this case.) The frequencies are now divided by the total number of observations for the day (forty here) to obtain the proportion of time spent performing tasks pertaining to job categories. To convert the proportion to a more useful measure, time, multiply each by 80 (the number of hours available in a work day multiplied by the number of people working).

What is now available is the approximate number of hours spent by the branch performing various categories of work for each day. This same procedure is updated for each day of the study and for each branch and command. The use of proportions to determine time facilitates grouping.

The procedure outlined in the example above was the exact procedure used to group and prepare data for input into a statistical analysis routine. For each job category, the number of minutes spent in that category served as an input to regression; a separate input was generated for each study day. For reasons to be discussed later, each job category of a branch was similarly analyzed but functioned as a totally separate input. This analysis was performed by branch and MAJCOM.

Another input that helped generate a data point for regression was the workload factor values. Prior to survey initiation, each command was asked to provide data on items considered as appropriate workload factors. As previously discussed, a listing of proposed workload factors can be found in Appendix E.

Figure 5 should help clarify the concepts of data grouping and inputs to regression. Shown in the figure is a plot of manhour and workload factors for a job category for a branch. This same concept must be extended for each job category in both the Housing and Services branches respectively.

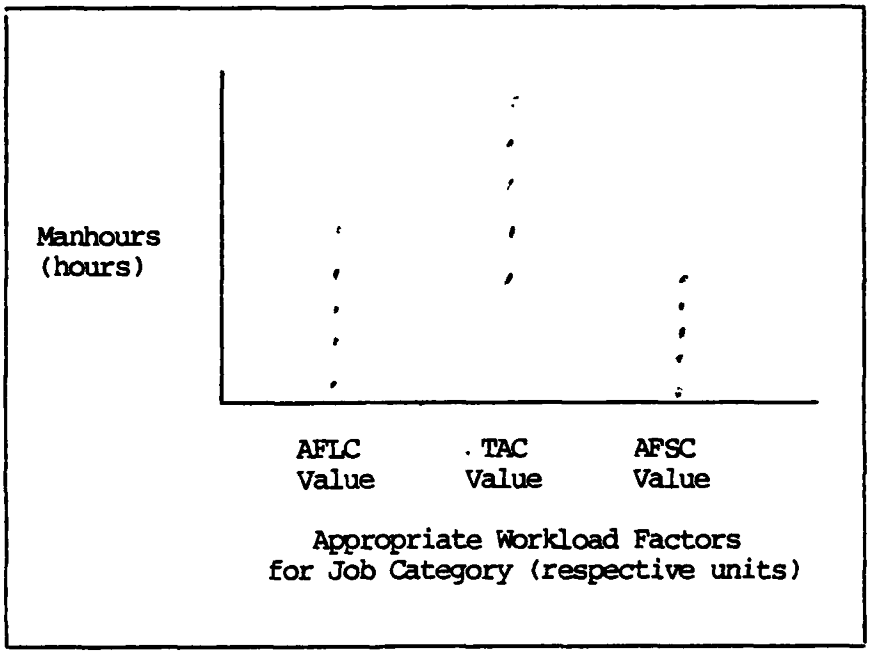


Figure 5. Plot of Predictor and Response Variables

Although data grouping enables identification of task distribution and proportions of time spent performing respective tasks across an entire branch, it caused problems with the sample sizes previously determined as statistically significant. In essence, 544 samples or observations per command were condensed into a total of sixty data points. This required a re-examination of statistical considerations to insure that sufficient samples were available to draw statistically

valid conclusions. The first consideration was to insure that sixty samples was satisfactory from a work sampling formula for sample size with an absolute accuracy of .03 (an Air Force Type I standard specification), a "p" value of .85 (percent of time usefully spent), and a Z value of 1.96, corresponding to a 95% confidence interval, yielded the original sample size of 544. Thus, grouping reduced the number of samples below that necessary for significance at the .03 absolute error level. Using the same formula with an absolute error of .09 yielded sixty required samples which was the exact number of samples available. This necessitated the use of Type II statistical criteria in lieu of Type I criteria earlier used. The less statistically precise standard was used hereafter because the extent of data grouping reduced statistical accuracy to a level slightly better than Type II specifications.

The other dealt with sufficient samples to permit a valid confidence interval. Applying the following formula for inferences regarding a normal distribution (sample greater than thirty permits this assumption) resulted in required sample sizes being greater than sixty when $\sigma > 100$ at .09 absolute error and $\sigma > 30$ at .03 absolute error. (A 95% confidence level was also used.)

$$n = \frac{Z_{\alpha/2}\,\sigma}{e}$$

where

n = required sample size
e = absolute error
Z = Z value corresponding to confidence level
σ = standard deviation of the sample distribution

Use of Regression. Regression analysis can be used to support various hypotheses. This research focused on the general linear hypothesis of determining the suitability of a developed equation to accurately represent relationship realities. To construct the relationship equation, a hypothesis that examines the significance of specific variables as predictors was used. These hypotheses are represented as follows:

$$H_o: \mu = b_0 + b_1x_1 + b_2x_2 + \ldots + b_ix_i + \epsilon$$
$$H_a: \mu \neq b_0 + b_1x_1 + b_2x_2 + \ldots + b_ix_i + \epsilon$$
$$\text{for } i = 1,n$$

and

$$H_o : b_j = 0$$
$$H_a : b_j \neq 0$$
$$\text{for } j = 1,n$$

Previously described test statistics were used to examine the hypotheses (21).

The ultimate goal was to define a manpower equation for each branch in terms of a categorical workload level that requires or sustains a certain level of manhours. A multiple number of categories could go into defining a relationship. This is the concept of modularity and is pictorially described in Figure 6.

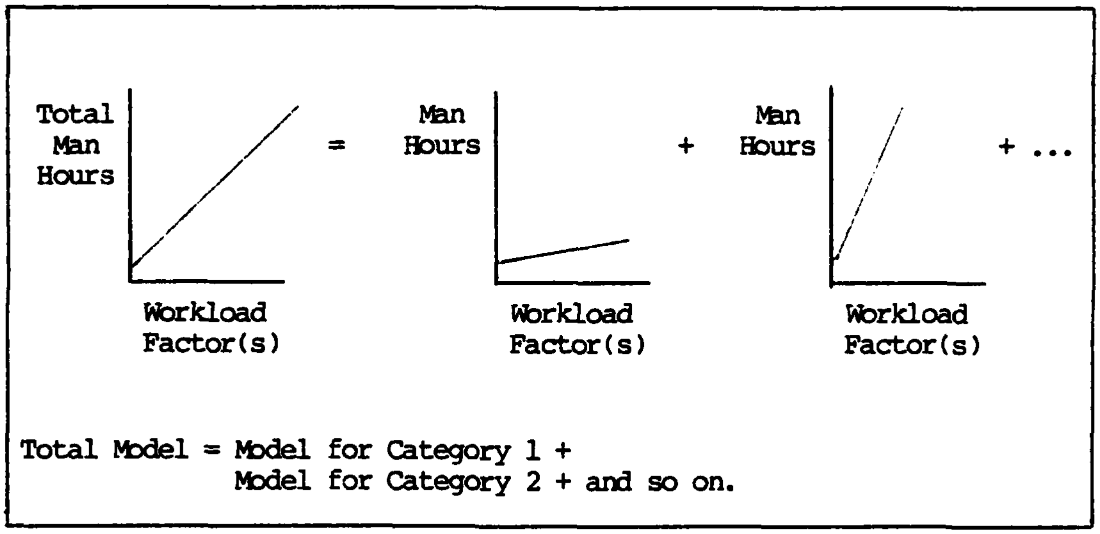


Figure 6. Modularity

Modularity permitted the development of a manpower standard (equation or model) for each job category as defined in AFR 85-7 and surveyed in this research (Appendix D). The development of each module used simple or multiple regression techniques depending on the number of potential workload factors used (Appendix E). Modularity required that each module be independent of every other module; that is, all work performed within a branch was included in a module but not more than one module.

In essence, modularity permitted a set of individual equations to define the work of a branch. A series of independent multiple regressions was used in this research to define a descriptive model based on each job category. Once all categories were defined, the branch model was simply a combination of the modules. This was done for each branch.

The standard approach to regression analysis as has previously been described was used in developing the modular equations for each branch. Essentially, the entire approach to regression was performed by a series of Statistical Package for the Social Sciences (SPSS) programs. A separate program was developed for each branch under study in order to make processing and analysis easier and not because required techniques varied. The coded programs can be found in Appendix H. Air Force test specifications were used in order to lend commonality to eventual application, but only a Type II significance could be achieved due to sample size restrictions. That is:

1. An alpha value of .1 was used for usefulness testing (F-test).
2. A minimum "R^2" value of .50

Before the SPSS programs could be developed and implemented, program specifications had to be determined. The specifications impact the structure of the data files as well as program composition and design.

The data file structures were the key to defining program composition. Each data file was composed of sixty lines or cases and represented the total number of samples taken. Each line contained the appropriate amount of time for each category and was divided into columns -- one column for each job category. Coupled with that, there was one column for each workload factor. A value of "9" was assigned to each column (representing a workload factor) that did not directly relate to an amount of time for the particular category. This

represented the "missing value" in SPSS terminology. Missing values were not used in any statistical calculations.

Two specific SPSS subprograms were used; they are Scattergram and Regression. The Scattergram routine produced a plot of input variable values that were regressed. The scattergrams were used to validate the assumption of a linear relationship between time requirements for each job category and the appropriate workload factors. The routine has a number of design specifications that were established. The range over which to plot values was made large enough to be inclusive of all values and still be able to show data trends. The range used varied for each workload factor. Additionally, calculations of the coefficients of correlation and determination were specified so as to be able to statistically check the visual interpretations made from the plots.

The regression subprogram was used to perform regression techniques on the data to develop useful manpower models by job category. In addition to various options and statistics, four different design specifications were made. For a detailed discussion of the specifcations, refer to the Statistical Package for the Social Sciences manual.

1. <u>Inclusion Level</u>: This level is used to determine which independent variable (workload factor) would first enter the routine. The default value of "1" was chosen so that each variable would be allowed to enter if it could pass statistical criteria. The order of entry would depend on variable significance.

2. <u>Method</u>: Stepwise regression was chosen.

3. <u>Parameters</u>:

a. The number of steps permitted in the routine was allowed to default.

b. The minimum value of the F distribution for the usefulness test statistic was set at 2.80. The value represented the lowest value of the test statistic that would permit model inclusion.

c. The tolerance level defaulted to its value of .001.

d. Akin to item b, the minimum value that the test statistic can take on before it was dropped from model inclusion was 2.79.

4. <u>Residuals</u>: The calculation of residual values was specified.

The SPSS program performed these tests for each job category in each branch studied across all commands studied. All statistically significant predictive values that combined to create a statistically significant model were used as the ideal model for each job category. That is, H_o was rejected if the selected α value has greater than the calculated significance. To obtain an ideal model for a branch, the individual, categorical models were summed.

The combined models from each branch were tested using workload factor data obtained from participating commands. The various, respective workload values were substituted into the developed equations to obtain a value for the manhours required for each branch. This figure is divided by sixty to obtain manhours as opposed to minutes. Each resultant value was divided by 143.5 -- the Air Force standard adjusted monthly manhours for military personnel (less leave, training, and

so on) (34). These values then represented the level of manpower required by the respective branches. Fractional requirements were determined by standard Air Force procedures, an extract of which can be found in Appendix G.

A prediction interval was calculated for each branch. The interval was used to determine the acceptability of the results of the desired model in relation to current MAJCOM staffing. A prediction interval seeks to define the range in which a particular relationship will remain valid given a level of statistical significance. In this case the prediction interval generated a range of acceptable manhours. Each limit was divided by the adjusted factor of 143.5 to obtain a range of manpower requirements. If the calculated range encompassed the level of current manning, the model was classified as acceptable. Otherwise, further research and analysis was recommend before acceptance could be assured.

Assumptions required for the use of regression have already been presented. This research satisfied these assumptions in the following manner thereby insuring the appropriateness of the technique to the research.

1. Before any workload factors were permitted as predictor variables, associated values and corresponding response values were plotted by the use of the SPSS Scattergram facility. The plot permits a visual examination of the relationship between the values. If it reveals a linear, straight line relationship, then a necessary condition is met. If not, mathematical transformations would be performed to obtain linearity.

2. As all data was numerical and in the form of time or work units, it was descriptive of a time state (e.g., time required to perform taskings). Additionally, numerical values assured location and relative position of observations. These factors together describe an interval level of measure, and this assumption was satisfied.

Validation of Techniques

The assumptions of linear regression are met by this methodology and its resultant model. The relationship between independent and dependent variables were examined through a scatterplot. Only variables that demonstrated a linear relationship were considered for further analysis. The number of residuals were greater than thirty thereby assuring normalcy by the Central Limit Theorem. Lastly, the data, by its nature, was interval.

The techniques of work sampling are an accepted method of measuring work. This study seeks to extend and apply these techniques. It must apply the techniques correctly for the study results to be accepted. Acceptance is rooted in the validity of the application. The proposal to use work sampling techniques demonstrates logic and consistency in that it encompasses the entire population of items measured. An example is the inclusion of all members of a branch under study in the sampling process. Results of the sampling are generalizable because of work sampling's foundation on statistical principles, the randomness of the sample observations, the large sample size with high constraints and specified accuracy, and the replication of the sampling procedure. These factors reduce the chance of measure bias

due to beginning the sample procedures. The value of 85% chosen for the "p" value in determining the sample size equated directly to the percentage of time that a worker should be productive. The foundation for this factor lies in standards allowance theory (1).

Validity of sampling technique could be threatened by a lack of cooperation on the part of the branch members. A potential problem of branch members in the correct interpretation and observation recording is present but not much of a factor because a person cannot consistently falsify recordings over an extended period of time. Procedures complied with Air Force and labor regulations so invalidation was minimized. The ability to generalize from these results may be hampered by seasonal or cyclic work that may not be present at time of measurement. The only way to solve this potential problem would be to extend the sampling period — which is not always possible. With careful consideration of these factors, the work sampling methodology is valid. The validity of work factors can be seen in their degree of collectibility and relatability determined through work sampling and statistical validity, respectively.

To further lend validity to work sampling methods and procedures, a modified diary form similar to that used by Mintzberg in his studies was included in this research. The diary portion was part of the Observation Recording Form and participants used it in the same manner as the job category section was used. The diary concept lended validity to sampling procedures in that results obtained can be compared to the results of similar studies. If both sets of results

are in general agreement, then work sampling results should be accurate; otherwise, accuracy could be questioned.

Although employed techniques were similar, subjects used are not quite the same and a distortion could have been caused by this. Mintzberg used executive personnel where as this research focused on staff personnel. Staffs could be considered managerial personnel by virtue of the fact that they function as experts in certain areas and are functional representatives. There still exists a difference between what an executive and a manager do, however.

How Research Questions Were Answered

The methodology presented here was designed to answer all research questions. The feasibility of developing a general manpower standard for MAJCOM Engineering and Services deputates can be seen only after the entire study process is finished and analyzed. Feasibility for developing a generic standard for any or all deputates was determined by study success. Success of the study includes proper problem scope, data validity, and the validity of the techniques employed to gather and analyze data. It also pertains to the idea that a standard just might not be appropriate. To answer the feasibility question, the whole study must be completed.

The appropriateness of the manpower standards developed by HQ AFRES for generalization to other MAJCOMs was determined by the pilot study. The purpose of the pilot study was to check appropriateness and determine areas that were not appropriate and the reason for the difference. This research question has essentially been answered.

Appropriate workload factors for inclusion in a descriptive manpower standard were determined by an SPSS program using multiple regression analysis, modularity, and data based on work sampling results. Factors were chosen by an analysis of job taskings in AFR 85-7, experience, and comments made in the pilot study. Factors that best meet the statistical criteria of regression analysis were deemed suitably appropriate.

As the work sampling data was analyzed across MAJCOMs involved in the study and the best, most descriptive factors chosen for the model, resultant equations are the most representative of manpower requirements.

After appropriate equations had been developed, the validity of their responses in relation to current manning levels were evaluated as part of the feasibility determination. This determination was based on a confidence interval estimation. Any values within the interval will be acceptable and so will the respective equation.

The validity of regression analysis stems directly from the statistical techniques and tests. If results obtained are not valid, they will not pass the statistical tests; therefore, validity is implicit.

IV. Findings

By applying the specific methodology discussed in Chapter III to the real world environment, a quantity of data was generated to develop manpower standards. The data needed to be sorted, analyzed, transformed, and processed in order to obtain results and draw conclusions. Presented here are descriptions of these operations and their results. Specifically covered are the pilot study, which was used to identify and localize problem areas, and the results associated with work sampling — raw data responses, problems, and coding. Additionally, the regression processes used will be presented as well as its end-products.

Pilot Study

In all, the pilot study proved that the HQ AFRES standards were not generally applicable, that a more generic standard was needed, and that standard development should begin in the area where the results were most inappropriate. It was for this latter reason that the Housing and Services directorate was chosen for study. Also impacting on this choice was the weakness of the workload factor used by HQ AFRES and that this Directorate lent itself more readily to study because of its size.

Raw Data Analysis

Analysis of data took on three distinct areas -- work sampling, workload factor determination, and data transformation (methodological considerations). Verbal feedback from points of contact and an examination of responses revealed that the conduct of work sampling was easy and instructions were clear. Random observation times were adhered to as best as could be expected without central control. Confusion did exist in category definitions. When discussing workload factors, it was apparent that there was some confusion as to the exact definition of the desired factor; some information also was not readily available.

Work Sampling Considerations. The calculations for the required number of observations per individual for each of the surveyed commands was based on ideal conditions -- i.e., full manning to authorized levels. This was not the case in all commands, notably AFLC and TAC. The reason for functions not manned at full strength during the survey were that a particular function was undermanned prior to the study or as a result of a permanent change of station for participating personnel during the study period. This resulted in achieving 73% of the sampling goal (i.e., number of observations taken versus number of observations required or 2,860 versus 3,660). All commands sampled less than required due to reduced manning or, in the case of AFSC, a partial failure to sample at all. Actual sample sizes were lower than those considered statistically valid at the chosen confidence level of 95% (i.e., 544 observations per command per period); dropping confidence to 75% resulted in a valid sampling. Statistical significance was not violated for the total number of samples; rather, the number of

observations that composed the total number of regressed samples was less than desired.

Throughout methodology development, there was great concern for the validity and accuracy of responses because each individual would be recording his own work observations. It was felt that with repeated observations, repeated misrepresentation would be minimized. False observations appeared not to be a problem because of the repeated number of observations and the serious involvement of participants and their superiors. Of a far greater concern, however, was the communication of sampling requirements which was an area not considered much of a potential problem. Instructions on how to handle situations such as TDY or leave as well as work category classification were explained in the instruction packet provided to each individual. Additionally, each surveyed MAJCOM point of contact was briefed on the procedures and any problems clarified. Nonetheless, situation and category interpretations resulted; participants were not always sure how to record events. The biggest problem areas were with TDY and categories not directly specified.

Observations were to be made during TDY's and recorded under the job category that most closely matched the trip. Not all commands did such nor was there any real consistency within commands. This resulted in whole days worth of data for an individual observer(s) to be missing.

With regard to job categorization, participants were asked to select the category of work shown on their observation form that best and most closely described what they were doing at the time of

observation. Again, not all participants did such; they were, however, in a vast minority (i.e., 3 of the 23 involved). These participants embellished their forms to the point that original work categories were not usable. They attempted to be explicitly descriptive of what they were doing and felt they could not directly relate it to the work category provided. For example, one created category was "briefing." This could have been easily classified in the specific area that the briefing was given, but was not. The classification actions can be attributed to not knowing the exact purpose of the research, not knowing the exact definition of work categories, and not using the proper observation forms.

Job categories were extracted from AFR 85-7, but not all of them were current given changing circumstances. Additional categories of Clothing and Services Information Management System, among others, would have been appropriate according to participants. They did, however, record work in these areas into defined categories.

All the interpretation problems presented could have lead to discrepancies within and across commands but none was readily apparent. With the exceptions as noted, categorization appeared consistent.

Some observation categories on the respective observation forms were realigned from one branch (and form) to the other because the specific function was performed in a different branch across MAJCOMs. This posed no problem in data collection because of the modular design of the process. The same tasks were being performed across the MAJCOMs, only in a different location within the division. (Note: there is a distinction between this and the creation of a new

category.) The realignment was mainly limited to AFSC with the Unaccompanied Transient Housing function being a prime example.

With regard to workload factor values obtained by questionnaire before actual sampling, communication and interpretation again appeared to be problems. Finer definitions of the extent of workload factors was needed to avoid interpretation problems. Question such as:

1. Should the number of kitchens also include crash and flight kitchens?

2. Should transient support figures include contract quarters?

3. From which year should budget data be taken?

4. Should MWR furnishings be included in dollar value and account costs?

The commands were advised to include any factor that related to the workload in question. Again, communication of need was considered satisfactory until tested.

Some data used for workload factors should have used an average value over a period of years instead of the latest available figure. This action would serve to smooth data and avoid random fluctuations that can be caused by changes in yearly values.

Some workload factors were not really applicable and were deleted from consideration. Specifically, TAC is the only command with reported food service contracts so this factor is not applicable to the study as a whole. Additionally, two of the three commands maintain leased housing, but the number is so small so as to make the entire category insignificant.

In spite of deviations from the original sample plan, the work sampling concept itself was validated through the use of the work

diary. The use and implementation of work sampling as a data gathering technique was deemed appropriate. A comparison of the diary contained in this study with those of historical studies revealed marked similarities in general trends; in only two areas were there noticeable disagreement (see "subordinates" and "meetings"). This disagreement was at least partially attributable to the addition of the "combination" and "other" categories in the condition and task portions respectively. The Condition time distribution in this study closely approximates that found in Stewart's study of middle managers. Considering a branch as a small group with a directorate or division, task time distributions are nearly equivalent to those listed for a small organization. Table II shows the results of historical studies while Table V presents the results of this study.

Methodological Considerations. In general, as much data as possible that was deemed acceptable and applicable was used in preparing the manhour expenditures. Not all data was considered acceptable because of attempts to define new job categories. Where possible, however, this data was salvaged by recategorizing it into something useful. Recategorization was performed only when it was clearly obvious that it could be done successfully; if not salvageable, the data was not used in any subsequent calculations. (An example of recategorization would be reclassifying "Review Contingency and O Plans" as "Mobility.") This action did tend to reduce the number of samples that comprised each data point.

As an extension of the above discussion, data was sometimes partitioned, either between inclusion or between branches. That is, if

Table V

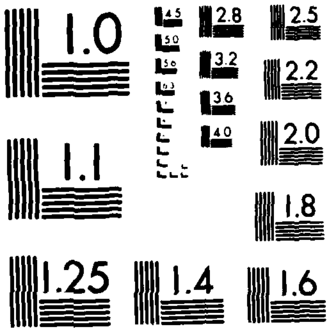
Category Recap for Comparison Survey

	Percentage of Time			
	AFLC	AFSC	TAC	Total
<u>Condition</u>				
Subordinate	8	3	2	2
Peer	15	2	8	8
Other Employee	5	1	8	5
Boss	2	8	8	6
Outsider	13	22	11	16
Combination	11	8	9	10
Alone	46	56	54	83
<u>Task</u>				
Meeting	13	21	18	15
Telephone	11	15	18	16
Desk Work	44	44	46	45
Touring	11	3	13	9
Other	21	17	5	15

AD-A147 111 AN INVESTIGATION INTO THE FEASIBILITY OF ESTABLISHING MANPOWER STANDARDSFF..(U) AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OH SCHOOL OF SYST.. M H BAILEY 2/2

UNCLASSIFIED SEP 84 AFIT/GEM/LSM/84S-2 F/G55/9 NL

END



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

a person was TDY and did not report what he was doing, his observation was not included for that day. His observations were included only for non-TDY days. A person TDY reporting what he was doing was included in all calculations. Sometimes people worked in modular categories; that is, the individual was assigned to one branch but performed duties from another branch. Only the observations attributable to each branch were included in their respective calculations. Appropriate calculations included the number of observations (to determine work percentage distributions) and the number of people (to determine work hour distribution). This was a slight change from the original methodology because little thought was given to the idea that one individual could be performing functions that eminate from different branches. Additionally, no allowances were figured in developing individual task times since an "indirect" category was provided. The "indirect" category can account for any time that would otherwise necessitate an allowance.

Some workload factors could have caused problems in the case of a command not maintaining the requested data while other commands did maintain the data. This was not a frequent occurrence but an occurrence nonetheless. This occurrence was coded as missing data and was not used in calculations. In some other cases, a command may have reported a value of "zero" for a particular workload factor while other commands reported far greater numbers. The factor was coded as a zero because that was its actual value; it is valid to be coded that way but appears inconsistent. For ease of manipulation, workload factor data

was rounded to the nearest hundreds, thousands, or millions, whichever was appropriate.

Appendix I presents a listing and description of workload factors that could have caused problems in data analysis or appear questionable. The coded data for each branch's SPSS programs follows in Appendix J.

Model Development

The SPSS program used to manipulate and analyze the data for both the Housing and Services functions used the classical regression approach previously presented. All appropriate procedures including scatterplotting, regression, and residual analysis were performed as well as obtaining all possible statistical options. Model development will be presented from both a general and specific standpoint. The general approach is necessary to lay groundwork for the specific discussion and will discuss findings in a developmental way. In this chapter, job categories and workload factors are referred to by their SPSS names. See Appendix D for a translation.

General Considerations. Results from both the Housing branch and the Services branch were reasonably similar in their general nature and trends. All variables tested in each function demonstrated a linear relationship with their respective workload factors. The degree of the relationship and its type (i.e., positive or negative) varied across variables and factors, but linear relationships still existed. Negative relationships were somewhat surprising but could be explained directly from data. The extent to which discovered relationships also

varied across dependent and independent variables; all relationship indicators were, however, found to be statistically significant. The scatterplotting function and its associated statistics, including coefficients of correlation and determination, were used to provide general guidance in determining linearity relationships.

The programs' regression function was able to determine regression coefficients, hence equations, for job categories that met the established statistical criteria. Most categories were described by an equation. The statistical significance of many of the resulting values, however, was questionable. Multicollinearity among most variables was noticeable; that is, many of the workload factors were directly related with each other. An examination of residual values for each job category that resulted from each regression equation revealed a distinct pattern. The pattern revealed that the dispersion of residual values was an increasing function of the independent variable. To rephrase, the variance of the residuals were dependent on the value of the plotted variable. By comparing these observations with their respective scatterplots, a heteroscedastic condition was confirmed. Heteroscedasticity refers to a condition where the variances of samples (or their residual error terms) are not statistically identical. This is a violation of the basic assumptions of regression and must be eliminated in order to fully exploit the strengths of regression techniques.

Before taking steps to eliminate heteroscedasticity, its presence had to be confirmed so that needless data transformations would not be generated. An SPSS program was developed to examine the respective

data of each branch by performing an analysis of variance for each workload factor against its manhour observations. Program results confirmed the presence of heteroscedasticity in all data sets.

In order to provide robust and complete regression results, heteroscedasticity had to be removed. Three approaches were tried using various schemes of weighted regression. Weighted regression seeks to weight data such that data variance among samples are equal or nearly equal. In effect, terms that have a large variance receive less weight while observations with small variances are weighted more heavily. Weighting seeks to reduce sample variances so that they are equal, thereby meeting basic regression assumptions. One weighted approach involved transforming data by multiplying each element by the reciprocal of the standard deviation of the respective category observations while another method sought to multiply the data by the square root of the associated observation value. Combining the two approaches resulted in multiplying data by the reciprocal of observation values believed to be mostly responsible for heteroscedasticity. All three approaches were attempted by transforming the data and inputting it into the appropriate programs. The first approach, using the inverse of the standard deviation, provided results that most closely related to the original data, so it was chosen for further examination.

One would expect some different results because of transformed data but general trends should remain intact. This was not the case because all relationships were greatly altered in both strength and type. What before had potential significance now had little or none.

Scatterplots and associated statistics demonstrated little or reduced linearity while regression models were even less significant. Multicollinearity still existed to the same degree; however, a residual analysis revealed a plot with a less discernible pattern. Once again, an analysis of variance for each workload factor against its manhour observations was performed so that the presence or lack of heteroscedasticity could be confirmed. Almost without exception, heteroscedasticity had been eliminated.

Weighted regression was successful in removing heteroscedasticity, but it also removed most traces of relationships. A question existed as to which set of data should be used to continue model development. Transformed data met all regression assumptions and was thoroughly statistically correct; however, resulting relationships were nearly meaningless. This could be indicative of there actually being no relationship between observations and workload factors, but such is not the case because coefficients of correlation and determination are all valid, unbiased, and significant if all other regression conditions are met regardless of the presence of heteroscedasticity. Resultant equations are still not valid for analytical or confidence purposes; accurate statistical tests could not be performed because of the chance of discovering false significance.

Because the weighted regression transform eliminated heteroscedasticity, a greater confidence could be placed in this data and its resulting models. This data had statistical significance so it was chosen for further evaluation. Although this data appeared to have eliminated all relationships, the relationships discovered by the

original data were still appropriate because heteroscedasticity causes only statistical significance to be questionable and nothing else. The data presented in Appendix J is the transformed data described here; Table VI shows the appropriate standard deviation values used in the transform. Because of transformation, the appropriate regression model appears as:

$$\frac{Y_i}{\sigma i} = b_0 \frac{1}{\sigma i} + b_1 \frac{X_i}{\sigma i} + \ldots + \frac{E_i}{\sigma i}$$

<u>Specific Considerations</u>. The previous section presented an overall view of various findings as they developed in the process of constructing the desired manpower models. This section explores areas more indepth. First, simple analyses of variance are presented so that the need for weighted regression can be seen. Next, regression considerations for both the untransformed and the transformed data is shown so it can be seen why further analysis was done on transformed data.

This section will describe the findings of the various statistical analyses performed by the SPSS programs; it will not explicitly make reference to any set of data results. Some appropriate data results will, however, be shown in the appendices. It is suggested that the reader review the appropriate tables or appendices in conjunction with its respective discussion. The following items are provided: Table VII - Results of Sample Variance Analysis; Appendix K - Representative Scatterplots of Job Category and Workload Factor Relationships; Table VIII - Tables of Correlation, Determination, and Significance Values

Table VI

Standard Deviation Values Used for Data Transformation

Branch	Category	Command Data	σ_i Value
Housing	UPH	AFLC	1.75
		AFSC	1.07
		TAC	8.08
	HRO	AFLC	.75
		AFSC	1.53
		TAC	3.18
	Funds	AFLC	1.00
		AFSC	2.99
		TAC	2.99
	Furnish	AFLC	.95
		AFSC	.37
		TAC	3.09
	MRC	AFLC	2.56
		AFSC	2.56
		TAC	1.43
	MFH	AFLC	1.78
		AFSC	2.13
		TAC	3.36
	SUSP	AFLC	.96
		AFSC	2.38
		TAC	-
Services	COM	AFLC	.79
		AFSC	.72
		TAC	2.10
	AAFES	AFLC	.30
		AFSC	.63
		TAC	1.52
	Food	AFLC	.41
		AFSC	.45
		TAC	2.38
	Mortuary	AFLC	.70
		AFSC	.95
		TAC	6.11
	Laundry	AFLC	2.22
		AFSC	.62
		TAC	2.27
	RIBS	AFLC	1.10
		AFSC	1.19
		TAC	5.66
	SUSP	AFLC	2.48
		AFSC	.13
		TAC	-

Before and After Data Transformation; Appendix L - Table of Intercorrelation/Multicorrelation Matrix; Appendix M - Scatterplot of Cumulative Residual Values. Due to the large number of individual scatterplots, Appendix K presents only one typical scatterplot for representative purposes.

Variance Analysis. In the Housing area, two tests were performed to analyze variance. One hypothesis tested checked for statistical significance of each individual workload factor within each job category while the other tested the homogeneity of their variances. The null hypotheses were that no difference existed and the goal was to fail to reject the hypotheses at the .1 level. Before transformation, all workload factors rejected both hypotheses meaning that there was a statistical significance for each workload factor (i.e., sufficiently descriptive) and that respective variances were not equal (hence heteroscedasticity). Results changed after transformation because only two job categories each rejected each hypothesis out of the seven categories tested. This proved that the data transformation reduced the heteroscedasticity problem dramatically but did not quite eliminate it; it did reduce previous WLF significances.

Similar results could be found within Services functions. Likewise, only two job categories of seven remained significant after transformation. See Table VII for a summary of the tests.

Regression Before Transformation. Table VII displays data presented in this portion of the chapter. Of the six possible relationships of categories and workload factors in the Housing area, six had a correlation ("r" value) coefficient of .5 or better. The

Table VII

Results of Simple Variance Analysis and Heteroscedasticity

H_o = No Significance $\quad$ H_a = Significance

Reject Ho if $F_{calc} > F_{table}$ where $F_{2,57,.1} = 2.3933$

$F_{1,58,.1} = 2.7914$

$F_{1,38,.1} = 2.8354$

Branch	Category	Factor	F_{calc} Before Transform	F_{calc} After Transform	F table
Housing	UPH	Spaces	19.720	.250	2.3933
		UPHSUP	19.720	.125	2.3933
		Transup	22.000	.008	2.8354
		Base 2	19.720	.143	2.3933
	HRO	Cust	4.725	1.795	2.3933
		List	4.725	1.795	2.3933
		Office	4.725	3.960	2.3933
	Funds	Dolval	8.839	5.546	2.3933
		Budgets	22.252	2.924	2.3933
	Furnish	Actnum	10.247	.533	2.3933
		Actual	10.247	.533	2.3933
	MRC	Curfac	15.471	1.977	2.7914
		Profac	15.471	1.977	2.7914
	MFH	MFHSPA	2.677	1.629	2.3933
		Base 1	2.677	1.628	2.3933
	SUSP	Susno	5.973	.436	2.8354
Services	COM	POP	3.164	.230	2.3933
		Salevol 1	3.164	.304	2.3933
		Corr 1	3.696	.374	2.8354
	AAFES	POPA	3.842	.611	2.3933
		Salevol 2	5.166	1.168	2.8354
		Corr 1	2.660	.544	2.8354
	Food	Meals	80.236	.480	2.3933
		Rations	80.236	1.075	2.3933
		Facility	80.236	.866	2.3933
	Mortuary	Cases	5.468	2.134	2.3933
		Honors	5.468	2.134	2.3933
	Laundry	UPHSUP	16.330	4.856	2.3933
		Contra 2	42.672	12.524	2.8354
	RIBS	Trans	53.125	5.738	2.3933
		Hours	53.125	5.738	2.3933
		Deploy	53.125	9.784	2.3933
	SUSP	Susno	2.396	2.446	2.8354

Table VII (continued)

H_o = No Difference H_a = Difference

Test for heteroscedasticity.

Reject H_o if $X^2_{calc} > X_{table}$ where $X_1^2 = 2.71$

$X_2^2 = 4.61$

Branch	Category	Factor	X^2_{calc} Before Transform	X^2_{calc} After Transform	X^2_{table}
Housing	UPH	Spaces	37.440	.001	4.61
		UPHSUP	37.440	.001	4.61
		Transup	50.454	-0-	2.71
		Base 2	37.440	.001	4.61
	HRO	Cust	17.04	17.016	4.61
		List	17.04	24.589	4.61
		Office	17.04	17.016	4.61
	Funds	Dolval	21.30	.010	4.61
		Budgets	22.49	.003	4.61
	Furnish	Actnum	33.74	.005	4.61
		Actual	33.74	.005	4.61
	MRC	Curfac	7.15	.711	2.71
		Profac	5.85	.711	2.71
	MFH	MFHSPA	4.14	.262	4.61
		Base 1	4.14	.157	4.61
	SUSP	Susno	13.59	.213	2.71
Services	COM	POP	13.96	.020	4.61
		Salevol 1	13.96	.039	4.61
		Corr 1	18.16	.039	2.71
	AAFES	POPA	40.33	.007	4.61
		Salevol 2	9.57	.014	2.71
		Corr 2	31.13	.003	2.71
	Food	Meals	35.18	.022	4.61
		Rations	35.18	.015	4.61
		Facility	35.18	.012	4.61
	Mortuary	Cases	45.61	6.547	4.61
		Honors	45.61	6.547	4.61
	Laundry	UPHSUP	13.63	1.450	4.61
		Contra 2	24.51	.001	2.71
	RIBS	Teams	31.14	.158	4.61
		Hours	31.14	.068	4.61
		Deploy	31.14	.158	4.61
	SUSP	Susno	84.04	51.680	2.71

Budget "r" value was the highest of all factors, registering at .658. These positive correlations are indicative of a good linear relationship that shows an increase in time spent in a job category to a complementary increase in a workload factor (i.e., a positive, linear relationship). Three more moderate relationships were recorded at an "r" value of .4. Four relationships, two positive and two negative, all registered better than .3. The two remaining relationships, all positive, registered under .3. Family Housing Management with Bases demonstrated the smallest "r" value at .236. Unaccompanied Personn Housing workload factors all had "r^2" values (coefficient of determination) of .3 to .4. Family Housing Management possessed the lowest "r^2" value at .05; the remainder of the values were within the given range. All coefficients proved significant at the .1 level.

Multicollinearity was very much in evidence in nearly all relationships. This implies that many workload factors were closely related and quite possibly interchangeable with little effect on the significance of relationships with a particular job category. One correlation registered at .55, negative, but the remainder registered at .91 or better.

Because of heteroscedastic data, a statistically significant inclusion level of 2.80 (F-test) was used with care because this type of data tends to find significance where none should exist. As such, six of the seven tested job categories had one or more workload factors pass the significance test to tentatively define a model. At least one factor was used in each category and a model was developed for each

category. The ultimate usefulness of the model, however, must be tested. This will be done in Chapter V.

As has been shown, residual plots (Appendix M) demonstrated heteroscedasticity. This plotting clearly shows that the variance of the error terms increase within the workload factor thereby causing a coned shaped distribution. This finding was the cause for data transformation. This can also be called autocorrelation, for which a Durbin-Watson test attempts to examine. A test value near 2 indicates little or no autocorrelation (9). The average Durbin-Watson value from the SPSS program was 1.55 -- somewhat shy of the ideal value of 2. The Maintenance, Repair, and Construction category was the closest to this goal with a test value of 1.75. The low Durbin-Watson test value substantiates those corresponding to the residual plotting, scatter-plotting, and simple analysis of variance findings.

The Services branch had seventeen workload factors with which to be concerned, all of which were strictly linear. In comparison to the Housing area, the Services function had far more relationships with "r" values greater than .5 but a lesser number at lower levels. Both Facility and Meal factors with the Food job category exhibited the highest correlation of any relationship with an "r" value of .85. There were four correlations greater than .5 while eight correlations registered in the .3 area. All other relationships were below .3 with the lowest "r" value, .003, provided by the Laundry function and the UPHSUP factor. The highest "r^2" found was .737 (with Food category versus Facility) while the lowest was .059 (by Suspense versus Susno).

All "r" values proved to be statistically significant thereby validating observed relationships.

Every relationship except one exhibited extreme multicollinearity in the same manner and degree as noted in the Housing branch results. The lowest intercorrelation value found was .734 (Rations by Facility) while all Commissary intercorrelations were 1.0. This same value was repeated for Contra 2 by UPHSUP.

Numerous models were generated through regression -- five of the seven relations tested. Again, usefulness of the resultant models will be tested in Chapter V.

Residual values formed a cone shaped distribution as seen and proved previously. Heteroscedasticity was present throughout the entire data set. The average Durbin-Watson value was 1.66 with the lowest being .828 (Food Service category) and the highest as 2.036 (Mortuary Affairs category). The average value is close to the ideal of 2 than Housing data was, but it is still far enough away to support heteroscedasticity findings.

In comparison, Services branch data was a bit more significant and meaningful than the Housing branch data across all indicators examined. Both data sets closely approximated each other and mirrored general trends which lent some credence to the entire survey.

<u>Regression After Transformation</u>. The data transformation altered the entire complexion of the regression process. All relationships between respective job categories and workload factors retained their linear relationships, but they were greatly altered. The relationships, or "r" value, ranged from a positive .23 to a negative

.29 in the Housing area. Of the sixteen relationships, eight were negative. Going together, "r^2" valu - were rather low -- ranging from 0 to .079. Relationship significance was shown in the Funds category and a portion of the HRO category.

Multicollinearity was in evidence in nearly all relationships, but not to the extent seen before transformation. Very few models were generated after transformation because their resultants could not pass the test for statistical significance (only three of seven). Again, the significance of the models were examined in Chapter V.

Residual plotting revealed a more general dispersion of points with some remaining heteroscedasticity. This finding is complimented by the previous homogeneity analysis result of greatly reduced hypothesis rejections after transformation. Although not perfect, the average Durbin-Watson test value for developed models was 1.69. Consult Table VII and Appendix M.

Again, all transformed Services branch relationships were linear and more positive. Only four categories demonstrated negative relationships. Correlation values ranged from a high of .498 to a low of .217. The determination values ranged from .248 to 0. The significance of the descriptive statistics were non-existent except for Laundry versus Contra 2 and all Prime RIBS relationships. The Mortuary category was nearly significant. These values were so highly significant before transformation that transformation did not alter their ultimate relationship. As before, multicollinearity was strongly in evidence in most relationships but in a reduced sense as before transformation. Models were developed for four of seven categories.

As seen in the Housing branch results and the homogeneity analysis, since heteroscedasticity continued in the data set even after appropriate transformation (see Table VII and Appendix M). The average Durbin-Watson test value for developed models was 1.57 -- still a distance from the goal of 2.

Comparison of Regressions. A comparison of regression processes performed before and after data transformation really does not reveal why transformed data was chosen for application. One must look further to discover the reason. Untransfromed data was extremely heteroscedastic thereby negating all statistical inferences and significances. Discovered relationships remained valid but to infer any further would have been questionable. Transformed data eliminated previous limitations and thus it became appealing for further use. It would, at first, appear that transformations eliminated previously discovered relationships and significances. Through the use of additional statistical manipulations (seen in Chapter V), this was not the case. It was for these that transformed data and their resulting models were used.

V. Analysis

Results have been obtained, relationships discovered, and potential problems identified. In order to construct appropriate manpower models, an analysis of the findings must be performed to insure that results support the hypothesis and enable achievement of the research objective. This chapter seeks to accomplish that end by explaining or attempting to explain the findings and comparing the findings to established analysis criteria. Only then can the specific research questions be answered, appropriate models developed, and specific objectives achieved. Specifically, this chapter will discuss data coding, workload and category relationships, multicollinearity, model selection, autocorrelation model verification, and the research questions.

Data Coding

The way data was coded could have had a far-reaching impact on the results of the SPSS analysis and ultimately, model development. Data coding difficulties not only include how an individual recording his observations interpreted how he was to classify them but also the interpretation of the raw data. Raw data interpretation deals with the reclassification and inclusion of responses that were not properly recorded.

It was difficult to determine if initial classifications were common across individuals and commands unless one were there to supervise the recordings. Misclassifications could be easily buried within the data -- not easily discernible or alterable. No one set of individual recordings, from any command, really stood apart from the others so there must have been some degree of commonality. This is not to say that no variance occurred as this was not the case. Within a command there appeared little variance among individual responses but at least some variance among command responses. This was evidenced by examining how individual commands handled TDY situations. TAC, for instance, reported TDY time strictly as TDY and not as productive time for survey purposes. AFLC started to classify TDYs as productive but were not consistent in so doing. (AFSC did not have any TDYs.) These possible inconsistencies in data classification could have skewed it, but to what degree is unknown. All data appeared generally as expected so large variances were doubtful. To further preclude difficulties, data was manipulated in certain ways.

Data manipulation was done by reclassification and exclusion. These actions could have skewed data but it is doubtful because they removed outlying responses and placed them into the main data stream or removed them totally from consideration. Because all coded data was based on percentages, minor inconsistencies would not cause dramatic skewness nor the exclusion of data.

One workload factor and one entire job category were dropped from consideration because of the possible effects of skewness in their respective individual models as well as a potential cumulative model.

Only one command, TAC, reported any contract food operations so this factor was inappropriate for consideration due to its limited application. If considered, it could have hampered the Food Service model by using a factor not representative of surveyed commands; the same impact would have occurred if AFLC and AFSC values were assigned as either missing or zero. Additionally, leased housing responsibilities across commands were so small as to be nearly negligible. Little time, relatively, was spent in these areas as confirmed by the workload factors of TAC and two each for AFLC and AFSC. That is why this job category was dropped from consideration. The potential statistically harmful effects of excluding this data do not outweigh the skewness that could have resulted from inclusion.

Workload and Category Relationships

As was shown when examining findings, most workloads and categories were found to be linearly related; all relationships were significant. This finding is not surprising because a goal of this study was to find factors that were descriptive of work performed in job categories. Without a linear relationship, it would be difficult to define a simple and appropriate descriptive factor. Workload factors were logically selected based on their potential for description and linearity. That linearity existed, regardless of degree, was understandable; it was expected. No minimum values for the coefficients of correlation and determination were established so relationships would make itself known through the regression process. What does need to be examined and explained, however, are the negative

linear relationships and any affects that may have resulted from data coding problems identified in Appendix N. Logically, negative relationships do not make sense regardless of their linearity. It did not seem logical for a workload factor to increase and yet require a decreased amount of time. That is, in effect, what a negative relationship indicates.

At first glance, negative relationships did not appear logical but valid explanations existed for all discovered. These potential flaws were a direct result of the way workload factor and manhour (job category) data came together. The differences in workload values directly corresponded with the distribution of time spent performing a particular work category. From this standpoint, negative relationships could be appropriate. Table VIII presents various relationship values.

Examining other areas identified as potential problems that have not already been covered revealed little adverse impact. The number of transients supported was coded as a missing AFLC value for Unaccompanied Personnel Management. This meant that the resulting scatterplot was based on only two samples. Normally, results from this type of situation should be cautiously considered; these results have an intuitive appeal in that they logically made sense. The validity of this relationship is secure on statistical and logical grounds; there were little adverse problems.

TAC's Furnishing Management account number workload factor was seventeen times larger than that of other commands. This, at first, appears as if it were a problem but is not really because it was just

Table VIII

Correlation, Determination, and Significance Values Before and After Data Transformation

Branch	Category	Factor	Before Transform r	Before Transform r^2	Before Transform Sig	After Transform r	After Transform r^2	After Transform Sig
Housing	UPH	Spaces	.639	.408	-0-	.005	-0-	.4844
		UPHSUP	.639	.408	-0-	-0-	-0-	.4995
		Transup	.606	.367	-0-	-.014	.0002	.4653
		Base 2	.625	.390	-0-	.010	-0-	.4693
	HRO	Cust	.351	.123	.0029	-.281	.0794	.0146
		List	.365	.134	.0020	-.256	.0659	.0238
		Office	.372	.138	.0017	-.243	.0594	.0303
	Funds	Dolval	-.312	.097	.0076	-.295	.0872	.0109
		Budgets	.659	.434	-0-	.054	.0029	.3405
	Furnish	Actnum	.504	.254	-0-	.037	.0014	.3876
		Actual	.500	.250	-0-	-.109	.0119	.2024
	MRC	Curfac	.459	.211	.0001	-.244	.0597	.0299
		Profac	.555	.308	-0-	.239	.0574	.0327
	MFH	MFHSPA	.241	.058	.0331	-.126	.0153	.1686
		Base 1	.236	.056	.0358	-.130	.0171	.1598
	SUS	Susno	.369	.136	.0096	.106	.0113	.2566
Services	Com	POP	.316	.099	.0069	.089	.0079	.2485
		Salevol 1	.314	.098	.0073	.043	.0018	.3720
		Corr 1	.304	.093	.0090	.098	.0097	.2721
	AAFES	POPA	.329	.108	.0050	-.144	.0208	.1356
		Salevol 2	.346	.119	.0144	-.173	.0298	.1433
		Corr 2	.338	.115	.0040	-.118	.0141	.2326
	Food	Meals	.854	.729	-0-	-.034	.0012	.3982
		Rations	.648	.421	-0-	-.004	-0-	.4857
		Facility	.858	.737	-0-	-.082	.0068	.2644
	Mortuary	Cases	.355	.126	.0027	-.217	.0473	.0475
		Honors	.397	.158	.0008	.009	-0-	.4714
	Laundry	UPHSUP	.004	-0-	.4893	-.280	.0786	.0150
		Contra 2	.727	.529	-0-	.498	.2479	.0005
	RIBS	Teams	.807	.651	-0-	.130	.0169	.1606
		Hours	.802	.643	-0-	.232	.0541	.0329
		Deploy	.805	.649	-0-	.202	.0407	.0610
	SUSP	Susno	.243	.059	.0649	.268	.0719	.0471

a matter of scaling on the independent axis which was not allowed to vary.

TAC reported no proposed facility housing units, but this did not alter the Profac workload value because it too was merely a matter of scaling.

AFLC's correspondence workload factor for Commissary and AAFES categories did exist, but were coded as zero. The zero value was more appropriate than missing values as the values did exist; they just did not amount to anything. A missing value would have meant that the data existed but was not available. This was not the case -- as reported. Both scatterplots yielded the expected positive linear relationships so no difficulties were obvious.

TAC values for AAFES sales volume, laundry contract, and suspense workload factors were not available and were coded as missing also. Again, resulting relationships were all positive and linear as expected but more credibility would have been added if all values had been available. No adverse impacts were noted.

Multicollinearity

Strong multicollinearity was present in the results from both branches. The presence of multicollinearity was not unexpected nor was it surprising; the extent and degree of its presence was startling, however. Its presence is totally explainable, but its effects on model development and selection were undeterminable. Because of the degree of multicollinearity found, model results were most assuredly affected to the point that some factors with good linear relationships were

found to be not significant in the presence of other factors. The one factor in the model may describe the relationship satisfactorily thereby leaving other factors little to describe even though they could have been equally as satisfactory of descriptors.

Multicollinearity is explainable through the choice of workload factors. The goal was to logically select factors that were truly indicative of positive, linear relationships. Only certain general items stood out as potential factors within the various job categories because there is only so much work performed within a category. Other workload factors were variations or near variations of a chosen, main factor or factors. Variations were tested to check which factors, in what combinations, may have been more descriptive than the main factor. This caused the evidenced multicollinearity as main factors, multiple main factors, and their variations all seem to measure nearly the same.

Multicollinearity existed in all Housing and Services branch categories that examined more that one workload factor. Multicollinearity was defined as any correlation coefficient greater than .3. Consult Appendix L for appropriate index values.

Model Selection

Certain statistical criteria have been specified in Chapter III that were appropriate to the evaluation of the SPSS-generated manpower models. After verifying a linear relationship, a workload factor could remain in a model as descriptive only if it passed the series of statistical tests. This was the final step in obtaining descriptive manpower models. If factors did not pass statistical tests, it did not

invalidate any possible linear relationships. It meant only that the particular factors were not sufficiently descriptive from a statistical significance standpoint to be useful in defining needed manhours.

Evaluative criteria used included an "r^2" value of .5 or better, statistically significant of the F-test relation at a .1 level, a decreasing mean square error value over the range of tested factors, and stability of regression coefficients from various factor additions. Remember, for a model to be considered at this point, it had to have an F-test value of at least 2.8 which represents the statistical significance of the relationship itself (i.e., descriptive abilities). The significance of the F-test, or of the criteria, dealt with the amount of confidence in or the correctness of the F-test statistic. It checked to see if the F-test statistic could be relied upon to make statistical determinations.

By applying selection criteria to SPSS results, the following categories were found to be sufficiently significant for model development and selection. Any category not specifically mentioned was not sufficiently significant.

Models were generated for the HRO, Funds, and MRC categories in the Housing Branch. Interestingly, only the Funds category was found to be significant after performing an analysis of variance test on transformed data. The HRO category remained heteroscedastic after transformation so it was dropped from further consideration. The remaining potential models met all established acceptance criteria except one and that is an "r^2" value of .5 or better. To try and obtain a more acceptable "r^2" value, a data manipulation is possible.

A low "r^2" value could be indicative of either a genuine weak relationship or a lack of descriptive power caused by the model (i.e., a lack of fit). To determine if this was the case, a manipulation can be performed as an adjustment made to the "r^2" value. The manipulation involves splitting a sum of squares value of error terms into two parts — that attributable to a lack of fit and that attributable to randomness. This formula:

$$\sum_{i=1}^{n} (Y_i^2) - \frac{\left(\sum_{i=1}^{n} Y_i\right)^2}{n}$$

where Y_i equates to an observation value (i.e., manhours in a given category) yields a sum of squares due to randomness. If this value were subtracted from a total sum of squares and the resultant divided by the total sum of squares, it would yield a "r^2" correction factor. The previous "r^2" value should be divided by the correction faction to obtain a new "r^2" which can be used in determining model accpetance. Coupled with this, lack of fit should be checked to insure that resultant models is descriptive. To do so, take the sum of squares due to error and subtract from it the priviously calculated value used above (i.e., the sum of squares due to randomenss), the resultant is the sum of squares due to lack of fit (with one degree of freedom). The degree of freedom for the randomness factor is merely the sum of squares error degress of freedom minus one. Taking the ratio of the respective mean squares yielded an F-statistic. The hypothesis tested was that a linear model was appropriate (i.e., fits). If it was rejected, a non-linear model may have been appropriate.

Table IX

Fit Testing and Revised r^2 Values

Branch	Category	Fit Value	F Value	Revised r^2 Value
Housing	Funds	59.209	2.7925	.1578
	MRC	162.400	2.7928	.0894
Services	Mortuary	25.586	2.7914	.1672
	Laundry	8.314	2.8354	.6424
	RIBS	23.200	2.7928	.1026

Armed with this information, it can be seen that the potential model for Funds and MRC do not meet "r^2" criteria even after adjustment. The models also do not provide a linear fit. No models were accepted for the Housing Branch in light of this analysis. Refer to Table IX.

Models were generated for Mortuary, Laundry, RIBS, and Suspense in the Services area. All categories except the last proved significant in the variance analysis. Heteroscedascity existed in the Mortuary and Suspense areas; they were immediately excluded from further analysis. The Laundry and RIBS categories met all selection criteria except the "r^2"; therefore, data manipulation was necessary.

As seen from Table IX, only the Laundry category produced an acceptable "r^2" value. A problem existed, however, in that fit testing revealed a lack of model linearity in both areas. It is for this reason that no adequate models could be developed.

The results of data transformation pointed out two things. Transformation caused relationships that appeared linear to become non-linear, or nearly so. This indicated that non-linear models might have been better suited for the data. Additionally, more data certainly would have validated the potential for non-linearity as one would now know whether non-linearity was caused by the data itself or the lack of sufficient data.

Not all factors with strong relationships were considered in models, as discussed, because of multicollinearity. Once the most significant factor was placed into the model, there was little left for the other factors to contribute to the descriptive process so they appeared insignificant. They may, in fact, not be insignificant; they may be as equally or nearly as equally descriptive as the included factor(s). Some excluded factors could have had potential to be good descriptors but not as good as the factor(s) in the model. If they were better, they would have entered the model to the exclusion of those that did. Refer to Appendix N for tables of calculations for regression models found significant.

Autocorrelation

The analysis of residual values from the representative models yielded grounds for autocorrelation and heteroscedasticity. Two types of residual analyses were done -- one with all computer-generated models regardless of stated acceptance criteria and one using just acceptable models on an individual basis. Each residual plot, whether cumulative or individual, revealed the same general trends and

characteristics. The increasing pattern of residual variance over the range of workload factors has been discussed and is shown in Appendix M (which contains both transformed and untransformed data plots). Additionally, the individual plots, not depicted in this report, demonstrated a skewness towards negative residual values with a much larger positive dispersion.

There was no doubt that autocorrelation and heteroscedasticity were present and little could be done to reduce its presence as previously discussed.

Model Verification

Models that should have evolved from the previous steps were to be verified as previously discussed. Since no models were selected as linear, there was little need to perform verification. Any verification stps would prove meaningless; therefore, no verification testing was performed.

Analysis of Research Questions

At the onset of this research, an objective was specified along with various, specific questions whose answers would be used to achieve the objective. Before this research can be considered complete, an analysis of its results in light of the specific questions and ultimate objective must be performed.

The initial problem stated that no set of generic manpower standards exist that were universally applicable to all MAJCOM Engineering and Services deputates. The goal was to investigate the

applicability of HQ AFRES-developed standards to all MAJCOM Engineering and Services deputates and, if necessary, develop appropriate, generic standards by using a linear model. The Housing and Services Directorate was chosen as a testbed for the application. In the final analysis, HQ AFRES standards were not generally applicable and no complete set of appropriate standards could be developed through this research. Modularity of job categories within an organizational level -- such as the Housing and Services branches -- could have permitted equations to be developed for branch responsibilities (i.e., categories). In essence, the objective of this research was only partially achieved. Specific relationships were defined but specific models developed were inappropriate given evaluative criteria. No series of models were developed to describe an entire branch responsibility.

With regards to specific research questions, the feasibility of developing generic manpower standards for all MAJCOM Engineering and Services deputates is still questionable. Clearly, command-specific standards can be developed because they currently exist. The idea of generic standards is more tenuous because this research was not a total, qualified success. The research identified areas and functions with relationships but did not develop acceptable manpower models and did not develop an entire model for the whole area studied. Standards development is feasible, as proven, but to be fully successful, changes must be made in the approach.

Appropriateness for generalization of the HQ AFRES standards was demonstrated in the pilot study initially conducted to determine feasibility, appropriateness, and applicability. Commands surveyed

were universal in their dislike of the HQ AFRES standards because they did not accurately nor adequately measure workloads regarded as representative of actual responsibilities. Results of an application of selected standards from the pilot study supported these thoughts as manpower levels varied drastically and were not consistent across functions and commands. Based on these observations, HQ AFRES models were not appropriate for generalization.

The research was to identify appropriately descriptive workload factors and did so with at least a modest amount of success. Factors chosen, tested, and selected possessed great intuitive appeal, and therefore, it was logical that a majority of factors demonstrated linear relationships with the variables they were attempting to describe (based on the use of untransformed data). Transformed data reduced the number of descriptive factors but still found some factors descriptive. Instead of identifying all appropriate workload factors, suffice it to say that all workload factors, shown in Appendix E, were sufficiently descriptive of respective job categories except: the dollar value of billeting fund budgets (Dolval), number of current Housing and Services facilities (Curfac), number of Housing branch suspenses (Susno), and AAFES stores sales volume (Salevol 2). Any relation with a correlation of less than .3 was considered weak. Only the following, however, were so descriptive as to be appropriate for inclusion in a manpower model: number of billeting budgets (Budgets), number of command kitchen/dining facilities (Facility), dollar value of laundry contracts (Contra 2), and the number of Prime RIBS teams (Teams). All of these factors are command specific.

Some representative equations were able to be produced for various job categories within the Housing and Services branch, but equations could not be developed for all job categories as some were statistically insignificant given tested workload factors. The equations developed were not entirely acceptable and, therefore, were rejected. Specifically, these areas included the Mortuary, Laundry and Prime RIBS job categories.

Because of the presence of heteroscedasticity in the data, there could be no validity testing of any resultant equations. Data transformations greatly reduced relationships. Any attempt at a confidence interval range would be superfluous as results would have been statistically invalid using untransformed data. Few resultants fo the transformed data met acceptable criteria. The fact that models were not developed for all modular job categories (much less acceptable models) contributed to evaluation/validation problems as only limited comparisons could be made to present staffing levels that encompass all job categories.

VI. Conclusions and Implications

Conclusion

This research sought to establish a generic manpower standard for MAJCOM Engineering and Services organizations with emphasis on the Housing and Services directorate. Because there is no set of generic manpower standards that apply to this type of organization, a void exists. Managers are not able to adequately and accurately plan and program manpower requirements, are missing utilization efficiencies, and are taking manpower actions without any quantifiable support. It was shown that command-specific standards that currently exist are inappropriate for general application; hence, the void remained. This research sought to fill this void by meshing work sampling and regression analysis techniques to develop mathematical models sufficiently descriptive of organizational workloads expressed as required manhours. Because of the need to make developed models generally applicable to all commands, a modular approach was used to help account for differences among commands. Modularity required breaking representative workloads into specific job categories and applying these techniques to the individual categories. The manhours required to perform various workloads could be transformed into manpower requirements. Because of the predictive nature of the models over their respective ranges, the manhours and, hence, manpower required to perform various functions could be determined. This would

give managers a tool in managing and utilizing their manpower resources.

This research did not entirely achieve the objective with which it started. Although a partial void still exists in the management of Housing and Services personnel resources, this research has laid initial groundwork for the problem solution. This research has explored the entire area of Housing and Services manpower modeling and has identified valid relationships and noted problems. Acceptable manpower models could not be developed for job categories because some areas examined along with the factors used to examine them just were not sufficiently or statistically valid to be useful. Additionally, problems with heteroscedastic data prevented full evaluation and validation. Although the outcome of this research was not as successful nor as rigorous as desired, it did define various relationships and served to broaden the scope of knowledge while narrowing the scope of future research. These are necessary preconditions to the achievement of the ultimate goal.

Practical and Policy Implications

From both a practical and a policy standpoint, this research does not have much of an impact. The fact that a generic standard is still required is proof of this. A practical view shows that either the research goal cannot ever be achieved or cannot be achieved given assumptions used and limitations encountered. The research goal can ultimately be achieved in light of the HQ AFRES study and the results of this research. If it could not, HQ AFRES personnel would not

have been able to develop a command-specific standard nor would this research have generated the models it did. The development of manpower models is practical given the above considerations.

This research has little impact in the area of application because it was not the success desired. This is more of a policy consideration in that the use of developed standards would be a matter of policy and would directly affect manpower policies. If the research were fully successful, the end products could be used to program manpower requirements or demonstrated manpower needs in times of force modifications. This could lead to policy guidance as to the specific members and mixes of personnel required to support operations. Examples could include the number of people to maintain on an operations staff versus engineering and services staff or a chaplain staff at the MAJCOM level. Additionally, the same logic could be used to establish Air Force-wide guidance as to staffing levels and functions of various directorates -- such as Housing and Services -- within the Engineering and Services deputates. There is potential for far-reaching impacts, on both a practical and policy level, for the ultimate objective of this type of research. This specific research has limited implications given its limitations.

Strengths

Two areas contributed directly and positively to the limited success of the research. The techniques used, work sampling and regression analysis, are the foremost tools in their field for this type of analysis. This thought was validated in Chapter II. These

techniques provided the most rigorous treatment of the data and helped make the chances of valid results as high as possible. The use of the techniques implies validity, credibility, and success, but is not guaranteed as technique application does enter into consideration as it did in this case.

Good cooperation and support was achieved from all points-of-contact and participants. Their positive approach and keen interest provided for the best possible data under the circumstances. They were genuinely concerned about data requests and observation classification, they wanted to be and tried to be as correct, accurate, and factual in their reporting as possible. This is not to say that all went smoothly; there were communication difficulties which resulted in misunderstandings. Some misunderstandings may have skewed results and changed significances of findings, but the potential was greatly reduced because of the support and cooperation.

Limitations

Three major factors placed limitations on this research, some of which could have impacted the final results. It is important to understand these limitations so that the range of result applicability is known. Additionally, if this research were to be repeated, operating limitations should be known so that the researcher can expect certain sequences to occur or can take steps to reduce or eliminate the limitations. In either case, the following three limitations were observed.

Communication and misinterpretation existed and could have caused problems. Finer, more specific, and more encompassing definitions of workload factor requirements would be necessary to insure that responses given from participants are common across all commands. This could also be extended to job category definitions and guidelines so that classification could have been made more exact and open to less interpretation. Recordings, reclassifications, and inclusion of some data could have had a skewing effect. In essence, better communication would be required, which is easier to say than achieve. A visit to each participating location would be a good starting point.

Some observations were included in certain categories that were grouped so well that identity was lost. There may be a need to generate some additional, new categories and replace some currently specified by regulation. This would reflect recent changes in areas of responsibilities.

One limitation that encompassed the entire research in comparison to other similar projects was the time span and extent of the survey. HQ AFRES was fully successful in developing a command-specific standard whereas this research was not as successful in defining generic standards. Four people spent over a year developing the HQ AFRES standard for a single command. All development was performed on location. This research was limited to under a year and involved one person surveying three separate commands not being on location for the surveys. This limitation is probably inherent in thesis work, but it clearly shows in comparison with other like research.

Refinements

This research demonstrated an application exists for these types of manpower models. There is a need for them to efficiently and effectively use manpower resources; a gap currently exists at the MAJCOM level. There is merit in the concept and this approach in particular. Bearing in mind the discussion above, this research could be easily repeated with hopefully better results, conclusions, and implications. The following recommendations are areas that nearly duplicate this research or closely parallel it; in either case, they are worthwhile projects for future consideration.

The first recommended refinement uses combinations of the various factors already described above. Consideration should also be given to the use of non-linear modeling. Maybe not all of these changes are necessary; they could be considered in various combinations. This research and exact same methodology could be used by expanding the number of surveyed commands to increase the total number of observations. This would mean either redoing all the research from the start or merely adding to the existing data base. Closely akin to this would be to increase the number of observations within a command and across all commands so as to get the desired degree of interval data confidence. Taking these actions in combination would only serve to better the study. Lastly, any refinement of category or work factor definitions would be of great benefit.

Developing standards based on wartime considerations or additive areas identified in Appendix C would be complementary research efforts. Both areas need consideration in order to fully and successfully

implement and integrate any future manpower models.

In a slightly different vein but presented when researching this thesis was the automation of existing base-level Civil Engineering manpower standards into the various, available computerized management systems. This would enable base level managers to assess the changes in manning levels based on potential changes in operating environments. It would also make for a faster and quicker annual reapplication of the standards.

Appendix A: Glossary

Additives: Work done that is not part of the basic work center's description and manpower standard.

Deviation: A situation affecting a work center that causes manhours required to do approved work to vary from those contained in a manpower standard.

Exclusion: Work categories not required in one or more activities but commonly required in other like activities.

Good Operator Timing: Time values obtained by measuring the time a qualified individual spends on a given activity.

Manpower Standard: A quantitative expression which represents a work center's manhour requirements in response to varying levels of workload. A standard also includes a description of work center tasks, and associated conditions on which the standard is built, as well as skill and grade requirements.

Methods Time Measurement: Procedure which analyzes manual operations or methods by the basic motions required to perform them and assigns to each motion a predetermined time standard which was determined by the nature of the motion and the conditions under which it was made (1).

Operational Audit: Work measurement technique consisting of one or more of the following techniques: good operator timing, estimate, standard time, and/or directed requirement.

Potential Workload Factors: Unit of measure consistently expressive of manpower required to accomplish quantitatively and qualitatively defined responsibilities of a work center.

Standard Time: Time necessary for a qualified worker, working at a normal pace under capable supervision and experiencing normal fatigue and delays to do a definite amount of work of specified quality while using a prescribed method.

Time Study: A work measurement method consisting of a careful time measurement of the task with a time-measuring instrument. The study is adjusted for any observed variances from normal effort to pace. Allows for adequate time for unavoidable delays, rest to overcome fatigue, and personal needs. Learning or progress may also be considered. Long tasks are broken down into short, homogeneous work elements, each of which is treated separately and combined with remaining elements.

Work Center: Personnel who use similar methods and operations to perform homogeneous work usually located in a centralized area. Usually a small activity within broad functional segment contributing to the same end product.

Work Center Description: Format that shows work center responsibilities.

Workload: Expression of the amount of work, identified by work units or volume, that a work center has on hand at any given time.

Work Sampling: Application of statistical sampling theory to the study of work systems. Characteristics of work performed are used to produce estimates of the amount of work and types of activity performed.

AAFES: Army and Air Force Exchange Service

AFLC: Air Force Logistics Command

AFR: Air Force Regulation

AFSC: Air Force Systems Command

ATC: Air Training Command

BEAMS: Base Engineer Automated Management System

CECORS: Civil Engineering Contract Reporting System

CONUS: Continental United States

DOD: Department of Defense

HRO: Housing Referral Office

MAC: Military Airlift Command

MAJCOM: Major Air Command

MCP: Military Construction Program

MFM: Military Family Housing

MWR: Morale, Welfare and Recreation

NAF: Non-Appropriated Funds

O&M: Operations and Maintenance

Prime RIBS: Primary Readiness in Base Services

P341: Type of Funding

SAC: Strategic Air Command

SPACECOM: Space Command

SPSS: Statistical Package for the Social Sciences

TAC: Tactical Air Command

TDY: Temporary Duty

UPH: Unaccompained Personnel Housing

Appendix B: Survey Instrument

AFIT/LSM 21 OCT 1983

Background Information for Manpower Effort

HQ AFLC/DE

1. One of the students in our Graduate Engineering Management Program, 1 LT Mark Bailey, proposes to work on a thesis pertaining to the development of manpower standards for MAJCOM Engineering and Services organizations. Specifically, he proposes to develop appropriate manpower standards for teh deputate branch levels.

2. While reviewing pertinent literature he discovered a recent, yet unpublished, study conducted by HQ AFRES that developed a single location standard applicable to HQ AFRES. He is presnetly attempting to determine if these standards are generally applicable to all CONUS MAJCOM Engineering and Services Organizations. To do this, he needs your assistance because as a functional manager, you are the only one qualified to determine the applicability of the HQ AFRES study to your organization. Attachment 1 details manpower standards for selected branches. Also included for comparative purposes is a HQ AFRES/DE organization chart. Request you review this information and respond to the questions shown below. Feel free to add any additional comments.

a. Examine the equations and workload factors:

1) Are the workload factors appropriate for and applicable to your MAJCOM (i.e., are they representative)?

2) Are the workload factors too specific? Could they be generalized and made applicable to your organization?

3) What workload factors appear satisfactory, if any, and what factors, if any, need restructuring and redefinition?

b. Apply the excerpted standards to your MAJCOM. (A brief example of how to apply a standard is given in Attachment 2.)

1) What is the standard strength recommended by the model for these branches at your MAJCOM?

2) What are the values of the workload factors used to calculate the standard values mentioned above?

3) What is the current authorized strength of each of these branches at you MAJCOM?

3. Your feedback will be used as basis for deciding if continued research effort is warranted. Lt Bailey has some specific thoughts as to the applicability of the study and is aware of potential limiting factors. He needs your inputs to validate or disprove his thoughts; otherwise, he will be unable to continue this line of research.

4. Lt Bailey will be contacting your staff shortly to clarify any questions they may have prior to responding. Please direct all inputs to: AFIT/LSM, Wright-Patterson AFB OH 45433, Attn: Maj Joseph Munter. Lt Bailey can be reached by contacting Maj Joseph Munter, his thesis advisor, at AV 785-5023.

SIGNED

ALAN E. M. TUCKER, Major, USAF
Program Manager, Graduate
Engineering Management
School of Systems and Logistics

3 Atch
1. Selected Standards
2. Application Example
3. Organization Structure Chart

APPLICATION OF HQ AFRES DEVELOPED MANPOWER STANDARD FOR

FAC 1731 - ENGINEERING STAFF

Where: $Y = 215.5 + 47.34X_1 + 7.496X_2$

And: X_1 = Number of AFRES host bases (10)

X_2 = Number of AFRES tenant unit locations (47)

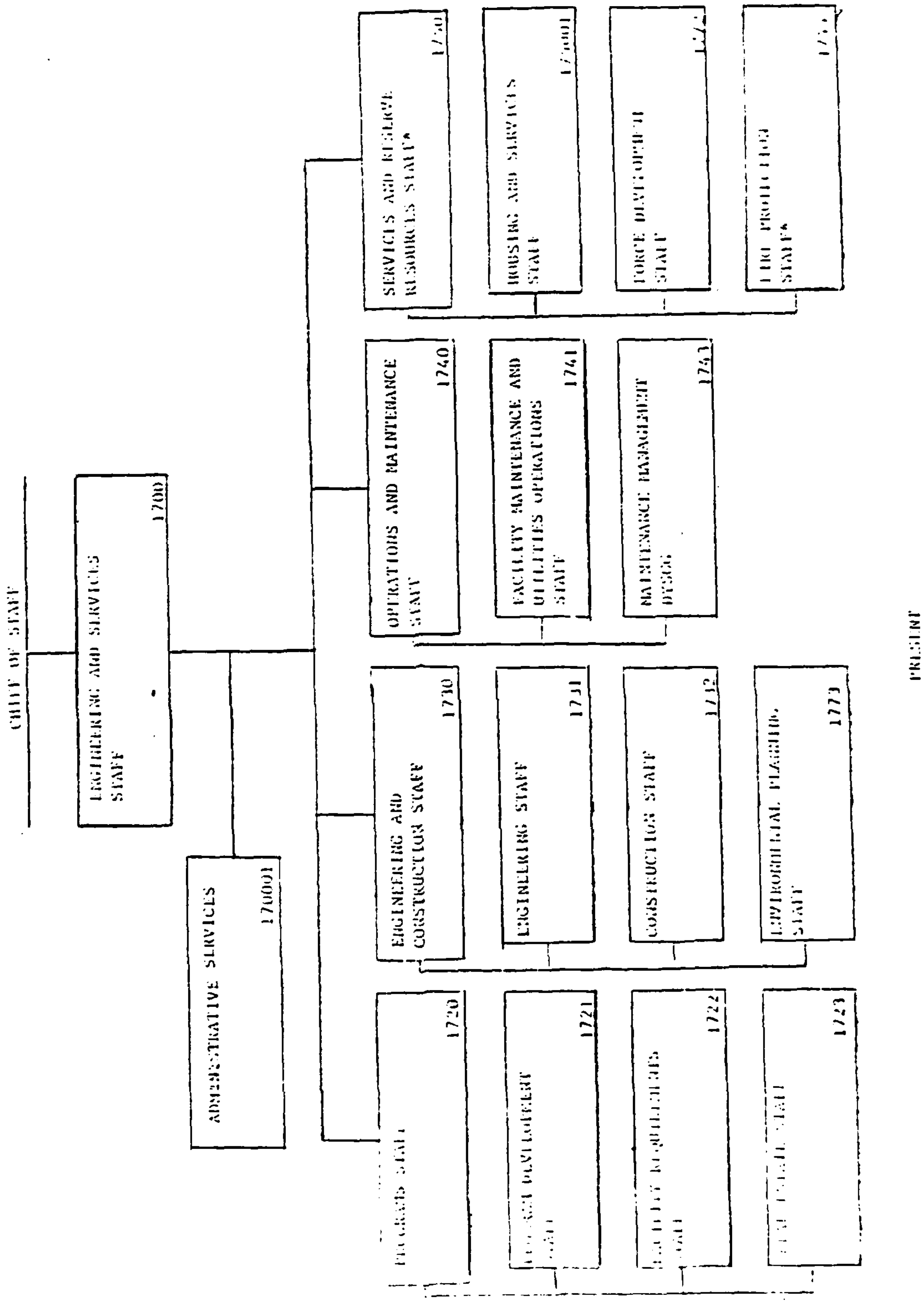
Therefore, total manhours =

$$215.5 + 47.34(10) + 7.496(47) = 1041.212$$

$$\text{Required manpower} = \frac{\text{Total Manhours}}{145.3}.$$

- OR -

$$\frac{1041.212}{145.3} = 7.1659$$


CHIEF OF STAFF
ENGINEERING AND SERVICES STAFF 1700
ADMINISTRATIVE SERVICES 170001
PROGRAMS STAFF 1720
1721
1722
1723
ENGINEERING AND CONSTRUCTION STAFF 1730
ENGINEERING STAFF 1731
CONSTRUCTION STAFF
ENVIRONMENTAL PLANNING STAFF
OPERATIONS AND MAINTENANCE STAFF 1740
FACILITY MAINTENANCE AND UTILITIES OPERATIONS STAFF 1741
MAINTENANCE MANAGEMENT
SERVICES AND RESOURCES STAFF
HOUSING AND SERVICES STAFF
FORCE DEVELOPMENT STAFF
FIRE PROTECTION STAFF
PRESENT

SELECTED MANPOWER EQUATIONS AND WORKLOAD FACTORS

Branch	Workload Factor(s)	Equation
Program Development (1721)	X_1 = Number of O + M projects developed for design and construction annually	$Y = 211.5 + 1.452X_1 + 1.382X_2 + .7141X_3$
	X_2 = Numer of MCP projects developed for design and construction annually	
	X_3 = Number of P-341, MFH and NAF projects developed for design and construction annually	
Real Estate (1723)	X = Number of bases	$Y = 65.84 + 18.52X$
Construction (1732)	X_1 = Number of host bases	$Y = 146.2 + 21.19X_1 + 3.739X_2$
	X_2 = Number of tenant locations	
Maintenance Management (1743)	X_1 = Number of host bases	$Y = 343.7 + 22.53X_1 + 13.41X_2$
	X_2 = Number of tenant locations	
Fire Protection (1745)	X_1 = Number of fire departments supported	$Y = 93.32 + 6.959X_1 + 3.642X_2$
	X_2 = Number of assigned CF 5/6 teams	
Housing and Services (1750)	X = Number of PRIME RIBS teams	$Y = 139.5 + 79.25X$

Note: Number of host units refers to the number of bases your MAJCOM has where it acts as host. Tenant refers to the number of locations where your MAJCOM is a tenant of another MAJCOM.

Appendix C: Procedures Used to Select and Group Structural Differences and Identify Potential Additives

If the MAJCOM has the same functions and organization as the standard of AFR 26-2,

then evaluate the function as a separate function

If the MAJCOM has the same functions but in different structural locations than the standard of AFR 26-2,

then evaluate the function as a separate function

If the MAJCOM has grouped one or more functions regardless of structural location,

then evaluate the function as a group

If the MAJCOM has split a function into two separate functions

then evaluate as separate functions,

If the MAJCOM structure includes optional or mission unique functions,

then identify the functions as additives which include:

- Missile Functions (SAC)
- AFMS Construction Functions (AFLC)
- Automated Information Systems (SAC, TAC, MAC)
- Interior Design (SAC, TAC, MAC)
- Facility Energy (AFLC)

Appendix D: Proposed Work Sampling Categories by Branch

The following listing gives the specific task categories used in work sampling analysis. These categories include time spent drafting, writing, rewriting, revising, editing, discussing, and examining materials, documents, letters, and reports. Also included are phoning, meeting, and briefing regarding these specified documents and associated contents. Time spent monitoring, enforcing, and resolving difficulties and discrepancies should also be included. Time required to budget for programs and projects and spent performing temporary duty, including meetings and workshops, are appropriate to these categories. The indirect category will include additional duties, training, and leave (categories extracted from AFR 85-7).

Directorate of Housing and Services

Housing Management	Services
Bachelor/Transient Management	Commissary Supervision
MFH Management	AAFES Supervision
HRO Management	Food Service
Leased Housing Management	Mortuary Affairs
Billeting Fund Management	Linen, Laundry, and Cleaning
Facility Maintenance, Repair and Construction	Headquarters/Congressional Suspense
Furnishings Management	Mobility
Headquarters/Congressional Suspenses	Indirect
Indirect	

Appendix E: Potential Workload Factors by Branch

Following is a list of factors that were tested to determine the relationship between workload and required manhours. These factors represent the predictive variable(s) in a linear regression application.

Housing Management

Code	Description
UPHSUP Transup	Number of UPH/Transient housing spaces, in hundreds
Spaces	Number of people supported in UPH and Transient quarters, in hundreds
Base 1	Number of bases assigned to a command
MFHSPA	Number of non-leased MFH units managed to include trailer spaces, in hundreds
Units	Number of leased housing units
Cust	Number of personnel handled through HRO annually, in hundreds
Office	Number of HRO offices
List	Number of listings maintained by each HRO, in thousands
Dolval	Dollar value of billeting funds managed, in millions
Budgets	Number of budgets managed
Actnum	Number of UPH and/or MFH furnishings accounts maintained
Actual	Dollar value of UPH and/or MFH furnishings accounts maintained, in millions
Curfac	Number of current facilities (MFH, UPH, Transient), in hundreds of spaces
Profac	Number of proposed facilities (MFH, UPH, Transient), in hundreds of spaces
SUSP	Number of suspenses, annually

Services

Code	Description
POP POPA	Base population to include dependents and retirees, in thousands
Salevol 1	Dollar sales volume of Commissary, in millions
Salevol 2	Dollar sales volume of AAFES, in millions
Corr 1	Count of correspondence pertaining to Commissary liaison
Corr 2	Count of correspondence pertaining to AAFES liaison
Meals	Number of meals served in dining halls, in millions
Facility	Number of dining facilities per base
Rations	Value of weighted rations, in thousands
Contra 1	Annual dollar value of restaurant contract operations, in millions
Contra 2	Annual dollar value of laundry/dry cleaning contracts for UPH, in thousands
Cases	Annual mortuary affairs case load
Honors	Annual number of requests for honors
UPHSUP	Number of personnel supported in UPH, in hundreds
Hours	Number of hours spent in Prime RIBS training, annually
SUSP	Annual suspenses
Teams	Number of Prime RIBS teams
Deploy	Number of Prime RIBS deployments, annually

Some of the potential workload factors may never reach the relatability phase of statistical testing as they may not be collectible. That is, data may not readily exist or may be too expensive to collect; therefore, the factor cannot be considered. Some factors may require an average over a period to smooth out wild fluctuations caused by a non-normal value. A factor such as "mechanical capacities" would be a very good potential factor, but it does not meet the collectible and relatable criteria given the categorical structure of the sampling plan. It would be difficult to equate the capacities of various systems because the units of measure are not the same (e.g., BTU vs KVa). It is for this reason that vague factors were not identified for consideration.

Appendix F: Sample Work Sampling Data Packet

Guidelines for Work Observations

1. This sheet provides you with information regarding this study and guidance for your participation. Keep the sheet handy for reference throughout the study.

2. _____________, who is acting as local study coordinator, will inform you when to begin the study. The study will run for two weeks (10 working days) and be repeated in the near future for the same length of time. Should you have any questions at any time, contact _____________, who can contact the researcher.

3. This study will have each person in your directorate, with the exception of the chief and administrative support personnel, record personal observations of his or her own work. These recordings will occur randomly throughout the day and will be recorded on provided information forms. There is a separate observation sheet for each day of the study. Please retain all sheets until the end of the study when _____________ will collect them. First, each form will be discussed; then, an example of how to use the forms will be presented.

4. Please examine the attached sheet entitled "Random Observation Table." This sheet displays the random times throughout the day at which you are to record your observations. You will notice that there are differant times for each day of the week. On the first day of the study, you would record observations of your activities at the times listed under the first column; on the second day, the second column would be used, and so forth. There are different sample times for each day and week of the study. As a hint, you might want to cross off lines as observations are taken. This will aid you in keeping observations straight.

5. The next sheet to examine is called the "Observation Recording Form," and this is where you record your observations. You will notice it contains two tables.

a. The first table (left), under "Category" is where you should record your observations. The categories shown refer to the general categories of job responsibility for your branch/directorate as described in AFR 35-7. To record an observation at a specified random time, simply place a check next to the category of work you were performing under the appropriate observation number column.

b. In the second table (right), you will see a section that pertains to "Condition." Each time you mark an observation, you should also mark this section. Place a check next to the appropriate condition and under the respective observation number as done before.

6. Each job category refers to a general classification of work as outlined in AFR 35-7. You should record your observation under the job category that best describes the work you are performing when a random observation occurs. Work that is inclusive to each category includes time spent drafting, writing, rewriting, revising, editing, discussing, and examining materials, documents, letters, and reports. Also included are phoning, meeting, and briefing. Time spent monitoring, enforcing, and resolving difficulties and discrepancies should also be included. Time

required to budget programs and projects, develop policies, and perform temporary duty, including meetings and workshops, are appropriate to these categories. The indirect category will include additional duties, teaching, leave, and lunch times.

7. The following definitions for "Conditions" are offered:

Peer: Someone on the same management level as you within your directorate.

Other Employee: Someone who is not your subordinate, peer, or boss within your directorate.

Outsider: Someone outside your directorate.

Boss: Immediate or higher.

8. Examples to help clarify procedures (also see attached sheets):

a. You are reviewing "leased housing policies" for ______________ when you notice from the "Random Observation Table" that it is time to record an observation of your work. You should do the following:

(1) Cross off the random time from the "Random Observation Table."

(2) On the "Observation Recording Form" you should place a check next to the "Leased Housing Management" box under the "Category" column and corresponding with the number of the observation taken. This involves the left table.

(3) Place a check next to the "Condition - Alone" entry found on the right side of the "Observation Recording Form" and a check next to "Desk Work."

(4) Resume normal activities.

b. Later in the day, you are talking by phone to the Air Staff regarding food service management. Once again you notice from the "Random Observation Table" that it is time to record another observation.

(1) Cross off the random time from the "Random Observation Table."

(2) Place a check next to the box corresponding to "Food Service" under the "Category" column of the "Observation Recording Form" and under the appropriate observation number (the left table once again).

(3) Since you are talking on the phone, place a check next to "Telephoning" under the "Condition" column on the right side of the "Observation Recording Form" and a check next to "Alone."

(4) Resume normal activities.

c. This cycle will repeat itself throughout the day and the study. The only other point to remember is that random observation times differ for each day of the study. You must be aware of this and use the times that are under the appropriate day of the week column.

RANDOM OBSERVATION TABLE - AFLC

Observation Number	WEEK 1				
	Monday	Tuesday	Wednesday	Thursday	Friday
1	0815	0830	0855	0815	0830
2	0915	0905	0930	0830	0920
3	0930	0915	0940	0930	1010
4	0945	0955	1055	0940	1050
5	1010	1050	1155	1040	1130
6	1030	1135	1230	1130	1140
7	1135	1155	1310	1140	1225
8	1150	1230	1325	1230	1310
9	1240	1355	1420	1300	1340
10	1255	1420	1420	1325	1415
11	1345	1500	1455	1450	1530
12	1540	1540	1530	1530	1555

Observation Number	WEEK 2				
	Monday	Tuesday	Wednesday	Thursday	Friday
1	0830	0910	0815	0830	0815
2	0930	0915	0855	0930	0830
3	1055	0945	0915	0940	0920
4	1155	1050	0930	1040	1010
5	1230	1135	1040	1130	1050
6	1300	1155	1130	1225	1130
7	1355	1230	1140	1310	1140
8	1400	1310	1230	1340	1230
9	1420	1325	1300	1430	1300
10	1500	1420	1325	1515	1325
11	1540	1435	1450	1530	1450
12	1555	1530	1530	1600	1530

RANDOM OBSERVATION TABLE - AFSC

Observation Number	WEEK 1				
	Monday	Tuesday	Wednesday	Thursday	Friday
1	0815	0830	0855	0815	0830
2	0900	0905	0930	0830	0920
3	0915	0915	0940	0930	1010
4	0930	0940	1050	0940	1050
5	0945	0955	1055	1040	1120
6	1010	1050	1145	1130	1140
7	1030	1135	1155	1140	1225
8	1135	1155	1230	1230	1310
9	1150	1230	1310	1300	1340
10	1241	1355	1325	1325	1355
11	1250	1420	1420	1415	1415
12	1345	1455	1420	1430	1445
13	1540	1500	1455	1450	1530
14	1600	1540	1530	1530	1555

Observation Number	WEEK 2				
	Monday	Tuesday	Wednesday	Thursday	Friday
1	0830	0810	0815	0830	0815
2	0910	0915	0855	0930	0830
3	0930	0945	0915	0940	0920
4	1055	1010	0930	1040	1010
5	1155	1050	1040	1130	1050
6	1230	1135	1050	1225	1130
7	1300	1155	1130	1310	1140
8	1355	1230	1140	1340	1230
9	1400	1310	1220	1415	1300
10	1420	1325	1230	1430	1325
11	1455	1355	1300	1450	1400
12	1530	1420	1325	1515	1440
13	1540	1455	1450	1530	1450
14	1555	1530	1530	1600	1530

RANDOM OBSERVATION TABLE - TAC

Observation Number	WEEK 1				
	Monday	Tuesday	Wednesday	Thursday	Friday
1	0835	0910	0930	0820	0930
2	1055	1025	0955	1040	1040
3	1315	1330	1055	1315	[illegible]
4	1415	1530	1355	1410	1530

Observation Number	WEEK 2				
	Monday	Tuesday	Wednesday	Thursday	Friday
1	[illegible]	0920	1000	0940	0810
2	[illegible]	1010	1050	1045	0930
3	[illegible]	1150	1155	1340	1355
4	[illegible]	[illegible]	1450	1425	1515

Day/Date ____________

OBSERVATION RECORDING FORM

MAJCOM/Office Symbol ____________

Category	Observation Number													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Bachelor/Transient Quarters Management														
Housing Referral Management														
Family Housing Management														
Leased Housing Management														
Billeting Fund Management														
Furnishings Management														
Facility Maintenance, Repair Construction														
Higher Headquarters/Congressional Inquiries														
[illegible]														

Condition	Observation Number													
With Whom?	1	2	3	4	5	6	7	8	9	10	11	12	13	14
• Subordinate														
• Peer														
• Other Employee														
• Boss														
• Outsider														
• Combination Above														
• Alone														
Doing What?	1	2	3	4	5	6	7	8	9	10	11	12	13	14
• Meeting														
• Telephoning														
• Desk Work														
• Touring														
• Other														

For definitions of categories and conditions, refer to your instruction sheet.

Day/Date ____________ MAJCOM/Office Symbol ____________

OBSERVATION RECORDING FORM

Category	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Commissary Supervisor														
AAFES Supervisor														
Food Service														
Mortuary Affairs														
Linen, Laundry, Cleaning														
Mobility														
Higher Headquarters Congressional Inquiry/Suspense														
Indirect														

Condition	1	2	3	4	5	6	7	8	9	10	11	12	13	14
With Whom?														
* Subordinate														
* Peer														
* Other Employee														
* Boss														
* Outsider														
* Combination Above														
* Alone														
Doing What?	1	2	3	4	5	6	7	8	9	10	11	12	13	14
* Meeting														
* Telephoning														
* Desk Work														
* Touring														
* Other														

For definitions of categories and conditions, [illegible]

Appendix G: Manpower Range for Each Availability Factor

MANPOWER RANGE FOR EACH AVAILABILITY FACTOR				MANPOWER
143.5/145.2 (NORMAL WORKWEEK)	180.0 (EXTENDED NORMAL WORKWEEK)	183.1 (EXTENDED REMOTE WORKWEEK)	244.0 (WARTIME EMERGENCY WORKWEEK)	
.001 - 1.077	.001 - 1.043	.001 - 1.040	.001 - 1.012	1
1.078 - 2.154	1.044 - 2.086	1.041 - 2.080	1.013 - 2.024	2
2.155 - 3.231	2.087 - 3.129	2.081 - 3.120	2.025 - 3.036	3
3.232 - 4.308	3.130 - 4.172	3.121 - 4.160	3.037 - 4.048	4
4.309 - 5.385	4.173 - 5.215	4.161 - 5.200	4.049 - 5.060	5
5.386 - 6.462	5.216 - 6.258	5.201 - 6.240	5.061 - 6.072	6
6.463 - 7.539	6.259 - 7.301	6.241 - 7.280	6.073 - 7.084	7
7.540 - 8.616	7.302 - 8.344	7.281 - 8.320	7.085 - 8.096	8
8.617 - 9.693	8.345 - 9.387	8.321 - 9.360	8.097 - 9.108	9
9.694 - 10.770	9.388 - 10.430	9.361 - 10.400	9.109 - 10.120	10
10.771 - 11.847	10.431 - 11.473	10.401 - 11.440	10.121 - 11.132	11
11.848 - 12.924	11.474 - 12.516	11.441 - 12.480	11.133 - 12.144	12
12.925 - 13.999	12.517 - 13.559	12.481 - 13.520	12.145 - 13.156	13
14.000 - 14.999	13.560 - 14.602	13.521 - 14.560	13.157 - 14.168	14
15.000 - 15.999	14.603 - 15.645	14.561 - 15.600	14.169 - 15.180	15
ETC.	15.646 - 16.688	15.601 - 16.640	15.181 - 16.192	16
	16.689 - 17.731	16.641 - 17.680	16.193 - 17.204	17
	17.732 - 18.774	17.681 - 18.720	17.205 - 18.216	18
	18.775 - 19.817	18.721 - 19.760	18.217 - 19.228	19
	19.818 - 20.860	19.761 - 20.800	19.229 - 20.240	20
	20.861 - 21.903	20.801 - 21.840	20.241 - 21.252	21
	21.904 - 22.946	21.841 - 22.880	21.253 - 22.264	22
	22.947 - 23.989	22.881 - 23.920	22.265 - 23.276	23
	23.990 - 24.999	23.921 - 24.960	23.277 - 24.288	24
	25.000 - 25.999	24.961 - 25.999	24.289 - 25.300	25
	26.000 - 26.999	26.000 - 26.999	25.301 - 26.312	26
	ETC.	27.000 - 27.999	.	27
		ETC.	.	28
			.	29
			.	.
			.	.
			.	.
			.	.
			.	.
			.	.
			80.961 - 81.972	81
			81.973 - 82.984	82
			82.985 - 83.996	83
			83.997 - 84.999	84
			85.000 - 85.999	85
			86.000 - 86.999	86
			ETC.	

Appendix H: SPSS Programs

```
RUN NAME          HOUSING BRANCH ANALYSIS
PRINT BACK        CONTROL
FILE NAME         HOUSING
VARIABLE LIST     CASENUM,UPH,HRO,MFH,LEASED,FUNDS,FURNISH,MRC,SUSP,INCIR,
                  CUST,OFFICE,LIST,UNITS,MFHSPA,BASE1,SPACES,UPHSUP,
                  TRANSUP,BASE2,DOLVAL,BUDGETS,ACTNUM,ACTVAL,CURFAC,
                  PROFAC,SUSNO
INPUT MEDIUM      CARD
N OF CASES        UNKNOWN
INPUT FORMAT      FREEFIELD
MISSING VALUES    CASENUM TO SUSNO (9)
VAR LABELS        CASENUM,CASE SEQUENCE NUMBER/HRO,HOUSING REFERRAL OFFICE-CAT/
                  LEASED,LEASED HOUSING OPERATIONS -CAT/
                  MFH, MILITARY FAMILY HOUSING OFFICE -CAT/
                  UPH,UNACCOMPANIED PERSONNEL -CAT/
                  FUNDS,BILLETING FUNDS MANAGEMENT -CAT/
                  FURNISH,FURNISHINGS MANAGEMENT -CAT/
                  MRC,MAINT REPAIR CONST WORK -CAT/
                  SUSP,SUSPENSED WORK -CAT/INCIR,INDIRECT CATEGORY/
                  CUST,HRO CUSTOMER COUNT -WLF/
                  OFFICE,NUMBER OF HRO OFFICES -WLF/
                  LIST,NUMBER OF HRO LISTINGS -WLF/
                  UNITS,NUMBER OF LEASED HOUSING UNITS -WLF/
                  MFHSPA,NUMBER OF MFH & TRAILER SPACES -WLF/
                  BASE1, NUMBER OF BASES -WLF/
                  SPACES,NUMBER OF UPH & TRANS BEDS -WLF/
                  UPHSUP,NUMBER OF PERSONNEL IN UPH -WLF/
                  TRANSUP,NUMBER OF TRANSIENTS -WLF/
                  BASE2,NUMBER OF BASES -WLF/
                  DOLVAL,DOLLAR VALUE BILLET FUND -WLF/
                  BUDGETS,NUMBER OF FUND BUDGETS -WLF/
                  ACTNUM,NUMBER OF FURNITURE ACCOUNTS -WLF/
                  ACTVAL,DOLLAR VALUE OF FURNITURE ACCOUNTS -WLF/
                  CURFAC,NUMBER OF CURRENT FACILITIES -WLF/
                  PROFAC,NUMBER OF PROPOSED FACILITIES -WLF/
                  SUSNO,NUMBER OF SUSPENSES -WLF/
TASK NAME         SCATTERGRAMS FOR LINEARITY CHECK-BY JOB CATEGORY
                  AND FACTORS
SCATTERGRAM       HRO WITH CUST,OFFICE,LIST/MFH WITH
                  MFHSPA,BASE1/UPH WITH SPACES,UPHSUP,TRANSUP,BASE2/
                  FUNDS WITH DOLVAL,BUDGETS/FURNISH WITH ACTNUM,ACTVAL/
                  MRC WITH CURFAC,PROFAC/SUSP WITH SUSNO/
OPTIONS           4,7
STATISTICS        1,2,3,4,5,6
TASK NAME         REGRESSION ANALYSIS BY JOB CATEGORY
REGRESSION        METHOD=STEPWISE/
                  VARIABLES=HRO,CUST,OFFICE,LIST/
                  REGRESSION=HRO(*,2.8,*,2.79) WITH CUST,OFFICE,LIST/
                  RESIDUALS/
                  VARIABLES=MFH,MFHSPA,BASE1/
                  REGRESSION=MFH(*,2.8,*,2.79)  WITH MFHSPA,BASE1/
                  RESIDUALS/
                  VARIABLES=UPH,SPACES,UPHSUP,TRANSUP,BASE2/
                  REGRESSION=UPH(*,2.8,*,2.79)  WITH SPACES,UPHSUP,TRANSUP,BASE2.
                  RESIDUALS/
                  VARIABLES=FUNDS,DOLVAL,BUDGETS/
                  REGRESSION=FUNDS(*,2.8,*,2.79)  WITH DOLVAL,BUDGETS/
                  RESIDUALS/
                  VARIABLES=FURNISH,ACTNUM,ACTVAL/
                  REGRESSION=FURNISH (*,2.8,*,2.79) WITH ACTNUM,ACTVAL/
                  RESIDUALS/
                  VARIABLES=MRC,CURFAC,PROFAC/
                  REGRESSION=MRC(*,2.8,*,2.79)  WITH CURFAC,PROFAC/
                  RESIDUALS/
                  VARIABLES=SUSP,SUSNO/
                  REGRESSION=SUSP(*,2.8,*,2.79)  WITH SUSNO/
                  RESIDUALS/
OPTIONS           11
STATISTICS        ALL
READ INPUT DATA
FINISH
```

```
RUN NAME          SERVICES BRANCH ANALYSIS
PRINT BACK        CONTROL
FILE NAME         SERVICES
VARIABLE LIST     CASENUM,COM,AAFES,FOOD,MORTUARY,LAUNDRY,RIBS,SUSP,
                  INDIR,POP,POPA,SALEVOL1,CORR1,SALEVOL2,CORR2,MEALS,
                  RATIONS,FACILITY,CONTRA1,CASES,HONORS,UPHSUP,
                  CONTRA2,TEAMS,DEPLOY,HOURS,SUSNO
INPUT MEDIUM      CARD
N OF CASES        UNKNOWN
INPUT FORMAT      FREEFIELD
MISSING VALUES    CASENUM TO SUSNO (9)
VAR LABELS        CASENUM,CASE SEQUENCE NUMBER/COM,COMMISSARY LIAISON -CAT/
                  AAFES,AAFES LIAISON -CAT/
                  FOOD,FOOD SERVICE FUNCTION -CAT/
                  MORTUARY,MORTUARY AFFAIRS FUNCTION -CAT/
                  LAUNDRY,LAUNDRY AND DRY CLEANING RESP -CAT/
                  RIBS,PRIME RIBS MOBILITY -CAT/
                  SUSP,SUSPENSED WORK -CAT/
                  INDIR,INDIRECT CATEGORY/
                  POP,BASE POPULATION INC RETIREES -WLF/
                  POPA,BASE POPULATION INC RETIREES -WLF/
                  SALEVOL1,COMMISSARY SALES VOLUME -WLF/
                  CORR1,COUNT OF COMMISSARY CORRESPONDENCE -WLF/
                  SALEVOL2,AAFES SALES VOLUME -WLF/
                  CORR2,COUNT OF AAFES CORRESPONDENCE -WLF/
                  MEALS,NUMBER OF MEALS SERVED -WLF/
                  RATIONS,NUMBER OF WEIGHTED RATIONS -WLF/
                  FACILITY,NUMBER OF DINING FACILITIES -WLF/
                  CONTRA1,$ VALUE OF FOOD SERVICE CONTRACTS -WLF/
                  CASES,MORTUARY AFFAIRS CASELOAD -WLF/
                  HONORS, REQUESTS FOR HONORS -WLF/
                  UPHSUP,PERSONNEL SUPPORTED IN UPHTRANS -WLF/
                  CONTRA2,$ VALUE LAUNDRY CONTRACTS -WLF/
                  TEAMS,PRIME RIBS TEAM NUMBERS -WLF/
                  DEPLOY,PRIME RIBS DEPLOYMENTS -WLF/
                  HOURS,PRIME RIBS TRAINING HOURS -WLF/
                  SUSNO,NUMBER OF SUSPENSES -WLF/
TASK NAME         SCATTERGRAMS FOR LINEARITY CHECK-BY JOB CATEGORY AND
                  FACTORS
SCATTERGRAM       COM WITH POP,SALEVOL1,CORR1/AAFES WITH POPA,SALEVOL2,
                  CORR2/FOOD WITH MEALS,RATIONS,FACILITY/
                  MORTUARY WITH CASES,HONORS/LAUNDRY WITH UPHSUP,CONTRA2/
                  RIBS WITH TEAMS,DEPLOY,HOURS/SUSP WITH SUSNO/
OPTIONS           9,/
STATISTICS        1,2,3,4,5,6
TASK NAME         REGRESSION ANALYSIS BY JOB CATEGORY
REGRESSION        METHOD=STEPWISE/
                  VARIABLES=COM,POP,SALEVOL1,CORR1/
                  REGRESSION=COM(*,2.8,*,2.79)  WITH POP,SALEVOL1,CORR1/
                  RESIDUALS/
                  VARIABLES=AAFES,POPA,SALEVOL2,CORR2/
                  REGRESSION=AAFES(*,2.8,*,2.79)  WITH POPA,SALEVOL2,CORR2/
                  RESIDUALS/
                  VARIABLES=FOOD,MEALS,RATIONS,FACILITY/
                  REGRESSION=FOOD(*,2.8,*,2.79)  WITH MEALS,RATIONS,FACILITY
                  RESIDUALS/
                  VARIABLES=MORTUARY,CASES,HONORS/
                  REGRESSION=MORTUARY(*,2.8,*,2.79)  WITH CASES,HONORS/
                  RESIDUALS/
                  VARIABLES=LAUNDRY,UPHSUP,CONTRA2/
                  REGRESSION=LAUNDRY(*,2.8,*,2.79)  WITH UPHSUP,CONTRA2/
                  RESIDUALS/
                  VARIABLES=RIBS,TEAMS,DEPLOY,HOURS/
                  REGRESSION=RIBS(*,2.8,*,2.79)  WITH TEAMS,DEPLOY,HOURS/
                  RESIDUALS/
                  VARIABLES=SUSP,SUSNO/
                  REGRESSION=SUSP(*,2.8,*,2.79)  WITH SUSNO/
                  RESIDUALS
OPTIONS           11
STATISTICS        ALL
READ INPUT DATA
FINISH
```

Appendix I: Areas of Concern for Workload Factors

Branch	Category	Description
Housing	Unaccompanied Personnel	AFLC transient support factor coded as missing
	Furnishing Management	TAC account number factor 17 times larger than other commands
	Maintenance, Repair and Construction	TAC does not have any family housing facilities proposed
	Suspenses	TAC factor coded as missing
Services	Commissary	AFLC correspondence factor coded 0
	AAFES	AFLC correspondence factor coded 0
		TAC sales volume factor coded as missing
	Food Service	TAC only command with reported food service contracts. Drop from analysis
	Laundry	TAC contract factor coded as missing
		Commands classified clothing workloads under this category although there is no separate workload factor to so identify
	Suspenses	TAC factor coded as missing

Appendix J: Computer Data

Untransformed Housing Data

```
1100 3.36 0 2.08 .64 .64 3.36 0 1.28 4.64 85.1 6 131.6 2 61.6 6  87.3
  57.6 9 6 7.1 24 19 10.3 62.8 203 800
1101 3.36 .64 4.64 .64 3.36 0 0 .64 2.04 85.1 6 131.6 2 61.6 6  87.3
  57.6 9 6 7.1 24 19 10.3 62.8 203 800
1102 1.28 0 0 0 0 0 1.28 0 13.14 85.1 6 131.6 2 61.6 6  87.3
  57.6 9 6 7.1 24 19 10.3 62.8 203 800
1103 2.27 .64 1.28 .64 .64 0 2.75 .64 6.08 85.1 6 131.6 2 61.6 6  87.3
  57.6 9 6 7.1 24 19 10.3 62.8 203 800
1104 2.08 0 2.08 0 .64 .64 2.08 .64 7.84 85.1 6 131.6 2 61.6 6  87.3
  57.6 9 6 7.1 24 19 10.3 62.8 203 800
1105 .64 0 6.08 .64 0 0 0 0 2.69 85.1 6 131.6 2 61.6 6  87.3
  57.6 9 6 7.1 24 19 10.3 62.8 203 800
1106 .64 .64 1.28 1.28 0 1.28 1.28 0 9.6 85.1 6 131.6 2 61.6 6  87.3
  57.6 9 6 7.1 24 19 10.3 62.8 203 800
1107 4.8 0 3.24 0 0 .64 0 1.28 4 85.1 6 131.6 2 61.6 6  87.3
  57.6 9 6 7.1 24 19 10.3 62.8 203 800
1108 2.08 0 4.64 0 0 .64 4 1.28 3.36 85.1 6 131.6 2 61.6 6  87.3
  57.6 9 6 7.1 24 19 10.3 62.8 203 800
1109 4.64 2.72 0 0 0 0 3.36 .64 4.64 85.1 6 131.6 2 61.6 6  87.3
  57.6 9 6 7.1 24 19 10.3 62.8 203 800
1110 5.64 0 1.8 0 0 0 .96 1.9 1.8 85.1 6 131.6 2 61.6 6  87.3
  57.6 9 6 7.1 24 19 10.3 62.8 203 800
1111 2.04 0 3 0 0 .96 0 3.6 2.04 85.1 6 131.6 2 61.6 6  87.3
  57.6 9 6 7.1 24 19 10.3 62.8 203 800
1112 0 2.04 0 0 3 0 3.6 .96 2.04 85.1 6 131.6 2 61.6 6  87.3
  57.6 9 6 7.1 24 19 10.3 62.8 203 800
1113 .84 0 3.6 0 1.56 .84 2.4 0 2.4 85.1 6 131.6 2 61.6 6  87.3
  57.6 9 6 7.1 24 19 10.3 62.8 203 800
1114 0 0 2.16 0 0 0 4.56 1.56 3.72 85.1 6 131.6 2 61.6 6  87.3
  57.6 9 6 7.1 24 19 10.3 62.8 203 800
1115 0 0 2.04 0 0 2.04 4.08 2.04 2.04 85.1 6 131.6 2 61.6 6  87.3
  57.6 9 6 7.1 24 19 10.3 62.8 203 800
1116 2.04 0 3 0 .84 0 2.04 2.04 2.04 85.1 6 131.6 2 61.6 6  87.3
 .57.6 9 6 7.1 24 19 10.3 62.8 203 800
1117 .72 0 2.4 0 .72 2.4 1.68 1.68 2.4 85.1 6 131.6 2 61.6 6  87.3
  57.6 9 6 7.1 24 19 10.3 62.8 203 800
1118 0 0 2.28 0 1.44 .72 3 2.28 2.28 85.1 6 131.6 2 61.6 6  87.3
  57.6 9 6 7.1 24 19 10.3 62.8 203 800
1119 0 0 0 0 0 0 0 0 12 85.1 6 131.6 2 61.6 6  87.3
  57.6 9 6 7.1 24 19 10.3 62.8 203 800
1201 0 1.08 0 0 .54 0 5.22 1.08 1.08 60.1 8 132.8 2 75.5 8 79.7 46.9
  102 8 5.1 32 26 12.3 62.6 342 150
1202 .54 0 9.45 0 2.52 0 1.99 2.7 1.78 60.1 8 132.8 2 75.5 8 79.7 46.9
  102 8 5.1 32 26 12.3 62.6 342 150
1203 3.24 .72 6.48 0 0 0 2.34 2.89 2.34 60.1 9 132.8 2 75.5 8 79.7 46.9
  102 8 5.1 32 26 12.3 62.6 342 150
1204 1.44 .54 3.06 0 1.98 .54 .54 4.5 4.5 60.1 8 132.8 2 75.5 8 79.7 46.9
  102 8 5.1 32 26 12.3 62.6 342 150
1205 .54 5.22 1.62 0 1.62 0 .54 1.06 2.14 60.1 8 132.8 2 75.5 8 79.7 46.9
  102 8 5.1 32 26 12.3 62.6 342 150
1206 1.8 3.43 4.14 0 0 .54 2.88 2.88 2.34 60.1 8 132.8 2 75.5 8 79.9 46.9
  102 8 5.1 32 26 12.3 62.6 342 150
1207 1.8 2.89 1.08 0 1.8 0 1.08 7.56 2.34 60.1 8 132.8 2 75.7 8 79.9 46.9
  102 8 5.1 32 26 12.3 62.6 342 150
1208 .54 0 5.4 3 .54 0 0 7.74 5.4 60.1 8 132.8 2 75.5 8 79.9 46.9
  102 8 5.1 32 26 12.3 62.6 342 150
1209 1.62 0 6.84 0 .54 0 2.42 3.42 2.16 60.1 8 132.8 2 75.5 8 79.9 46.9
  102 8 5.1 32 26 12.3 62.6 342 150
1210 0 3.06 3.78 0 .72 0 8.82 6.48 2.52 60.1 8 132.8 2 75.5 8 79.7 46.9
  102 8 5.1 32 26 12.3 62.6 342 150
1211 1.44 0 5.98 0 .72 0 1.98 1.2 .72 60.1 8 132.8 2 75.5 8 79.7 46.9
  102 8 5.1 32 26 12.3 62.6 342 150
1212 1.08 0 2.28 0 1.8 0 4.08 1.08 .6 60.1 8 132.8 2 75.5 8 79.7 46.9
  102 8 5.1 32 26 12.3 62.6 342 150
1213 2.04 0 5.36 0 0 .6 3.36 5.22 1.32 60.1 8 132.8 2 75.7 8 79.7 46.9
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  102 8 5.1 32 26 12.3 62.6 342 150
1215 1.8 0 3 0 1.8 0 3 1.2 1.2 60.1 8 132.8 2 75.5 8 79.7 46.9
  102 8 5.1 32 26 12.3 62.6 342 150
1216 2.85 0 0 0 0 0 9.12 0 0 60.1 8 132.8 2 75.5 8 79.7 46.9
  102 8 5.1 32 26 12.3 62.6 342 150
1217 0 0 .72 0 .72 0 10.56 0 0 60.1 8 132.8 2 75.5 8 79.7 46.9
  102 8 5.1 32 26 12.3 62.6 342 150
1218 3.12 0 3.12 0 0 .6 3.12 2.52 .6 60.1 8 132.8 2 75.5 8 79.7 46.9
  102 8 5.1 32 26 12.3 62.6 342 150
1219 0 0 3.48 0 1.32 0 6.26 0 .72 60.1 8 132.8 2 75.5 8 79.7 46.9
  102 8 5.1 32 26 12.3 62.6 342 150
1220 .6 0 2.52 0 .6 .32 .64 .6 .6 60.1 8 132.8 2 75.5 8 79.7 46.9
  102 8 5.1 32 26 12.3 62.6 342 150
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  18 5.3 72 311 41 244 30 9
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  18 5.3 72 311 41 244 30 9
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  18 5.3 72 311 41 244 30 9
1308 15 0 9.6 0 7.2 2.11 0 0 4.8 258.4 26 280 0 240 47 297 202 120
  18 5.3 72 311 41 244 30 9
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  18 5.3 72 311 41 244 30 9
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  18 5.3 72 311 41 244 30 9
1319 4.32 2.16 6.48 0 2.16 2.16 2.16 0 .48 258.4 26 280 0 240 47 297 202 120
  18 5.3 72 311 41 244 30 9
1320 2.3 2.8 5.8 0 9.6 0 0 0 0 258.4 26 280 0 240 47 297 202 120
  18 5.3 72 311 41 244 30 9
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Untransformed Service Data

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  343 57.6 909.8 0 0 5.5 800
2102 0 0 3.36 0 4.64 2.08 .64 7.44 121 121 151 9 79 9 2.7 800 10 0 102
  343 57.6 909.8 0 0 5.5 800
2103 0 0 0 .64 5.44 .64 .64 4.64 121 121 151 9 79 9 2.7 800 10 0 102
  343 57.6 909.8 0 0 5.5 800
2104 0 0 3.36 0 0 1.28 0 3.36 121 121 151 9 79 9 2.7 800 10 0 102
  343 57.6 909.8 0 0 5.5 800
2105 3.36 0 0 1.28 0 0 0 3.36 121 121 151 9 79 9 2.7 800 10 0 102
  343.57.6 909.8 0 0 5.5 800
2106 .64 0 3.36 0 0 1.28 1.28 9.44 121 121 151 9 79 9 2.7 800 10 0 102
  343 57.6 909.8 0 0 5.5 800
2107 0 .64 6.72 .64 3.36 .64 0 0 121 121 151 9 79 9 2.7 800 10 0 102
  343 57.6 909.8 0 0 5.5 800
2108 0 0 2.72 2.88 3.36 0 11.28 6.56 121 121 151 9 79 9 2.7 800 10 0 102
  343 57.6 909.8 0 0 5.5 800
2109 0 0 6.08 0 0 0 1.28 .64 121 121 151 9 79 9 2.7 800 10 0 102
  343 57.6 909.8 0 0 5.5 800
2110 0 0 4.64 0 0 .64 .64 2.08 121 121 151 9 79 9 2.7 800 10 0 102
  343 57.6 909.8 0 0 5.5 800
2111 0 0 3.36 0 .76 4.32 .48 2.90 121 121 151 9 79 9 2.7 800 10 0 102
  343 57.6 909.8 0 0 5.5 800
2112 0 0 5.04 0 2.4 0 0 4.56 121 121 151 9 79 9 2.7 800 10 0 102
  343 57.6 909.8 0 0 5.5 800
2113 .89 .48 .18 0 4.56 .84 .48 4.56 121 121 151 9 79 9 2.7 800 10 0 102
  343 57.6 909.8 0 0 5.5 800
2114 1.08 0 3.48 0 1.08 0 0 3.46 121 121 151 9 79 9 2.7 800 10 0 102
  343 57.6 909.8 0 0 5.5 800
2115 0 0 0 0 4.8 0 0 7.2 121 121 151 9 79 9 2.7 800 10 0 102
  343 57.6 909.8 0 0 5.5 800
2116 0 0 0 0 6.84 0 0 5.16 121 121 151 9 79.9 2.7 800 10 0 102
  343 57.6 909.8 0 0 5.5 800
2117 0 .48 3 0 2.05 .48 .48 5.52 121 121 151 9 79 9 2.7 800 10 0 102
  343 57.6 909.8 0 0 5.5 800
2118 0 1.08 2.64 0 3 .6 .6 4.08 121 121 151 9 79 9 2.7 800 10 0 102
  343 57.6 909.8 0 0 5.5 800
2119 0 0 4.2 0 1.2 1.8 0 4.8 121 121 151 9 79 9 2.7 800 10 0 102
  343 57.6 909.8 0 0 5.5 800
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  343 57.6 909.8 0 0 5.5 800
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  57 627 47 202 5 5 25 150
2202 0 0 6.14 .56 0 3.05 0 4.2 77 77 109 80 63.2 50 1.98 780 14 0
  57 627 47 202 5 5 25 150
2203 0 .56 7.84 0 .56 0 0 5.04 77 77 109 80 63.2 50 1.98 780 14 0
  57 627 47 202 5 5 25 150
2204 0 0 3.64 2.04 0 1.54 0 5.08 77 77 109 80 63.2 50 1.98 780 14 0
  57 627 47 202 5 5 25 150
2205 0 .56 5.18 2.1 0 .56 0 5.87 77 77 109 80 63.2 50 1.98 780 14 0
  57 627 47 202 5 5 25 150
2206 0 1.82 4.2 .56 .56 1.26 0 5.46 77 77 109 80 63.2 50 1.98 780 14 0
  57 627 47 202 5 5 25 150
2207 0 0 7.38 .7 0 2.28 0 1.14 77 77 109 80 63.2 50 1.98 780 14 0
  57 627 47 202 5 5 25 150
2208 2.38 1.12 3.5 1.12 0 .56 0 5.32 77 77 109 80 63.2 50 1.98 780 14 0
  57 627 47 202 5 5 25 150
2209 2.1 0 2.36 .42 0 2.1 0 6.72 77 77 109 80 63.2 50 1.98 780 14 0
  57 627 47 202 5 5 25 150
2210 0 0 2.24 0 .7 1.68 0 9.38 77 77 109 80 63.2 50 1.98 780 14 0
  57 627 47 202 5 5 25 150
2211 0 .38 .36 2.4 2.4 2.88 0 2.88 77 77 109 80 63.2 50 1.98 780 14 0
  57 627 47 202 5 5 25 150
2212 0 0 3.24 1.08 .6 1.68 0 5.4 77 77 109 80 63.2 50 1.98 780 14 0
  57 627 47 202 5 5 25 150
2213 0 0 3.6 1.44 1.44 .72 0 4.56 77 77 109 80 63.2 50 1.98 780 14 0
  57 627 47 202 5 5 25 150
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  57 627 47 202 5 5 25 150
2215 0 1.92 3.6 1.5 0 0 .5 4.8 77 77 109 80 63.2 50 1.98 780 14 0
  57 627 47 202 5 5 25 150
2216 0 1.2 3.36 1.68 0 2.88 0 2.48 77 77 109 80 63.2 50 1.98 780 14 0
  57 627 47 202 5 5 25 150
2217 0 0 3.12 2.04 0 2.64 0 4.28 77 77 109 80 63.2 50 1.98 780 14 0
  57 627 47 202 5 5 25 150
2218 1.2 1.2 5.64 1.2 0 1.2 0 1.56 77 77 109 80 63.2 50 1.98 780 14 0
  57 627 47 202 5 5 25 150
2219 0 0 2.01 2.52 0 2.64 0 5.4 77 77 109 80 63.2 50 1.98 780 14 0
  57 627 47 202 5 5 25 150
2220 0 0 3.6 3.12 0 4.66 0 2.52 77 77 109 80 63.2 50 1.98 780 14 0
  57 627 47 202 5 5 25 150
2301 0 3.84 39.04 3.84 0 15.36 0 1.92 949 949 360 325 9 730 10.4 1200
  72 13.5 262 2388 202 9 60 25 134 9
2302 0 2.24 23.52 4.48 4.48 21.28 0 0 949 949 360 325 9 730 10.4 1200
  72 13.5 262 2388 202 9 60 25 134 9
2303 0 0 29.28 2.4 4.8 11.52 0 0 949 949 360 325 9 730 10.4 1200
  72 13.5 262 2388 202 9 60 25 134 9
2304 0 0 29.88 0 4.72 15.12 0 4.48 949 949 360 325 9 730 10.4 1200
  72 13.5 262 2388 202 9 60 25 134 9
2305 0 0 12 4.8 2.4 4.8 0 0 949 949 360 325 9 730 10.4 1200
  72 13.5 262 2388 202 9 60 25 134 9
2306 2.4 0 4.8 2.4 6.4 17.6 2.4 0 949 949 360 325 9 730 10.4 1200
  72 13.5 262 2388 202 9 60 25 134 9
2307 2.8 0 13.2 5.2 2.8 10.8 0 5.2 949 949 360 325 9 730 10.4 1200
  72 13.5 262 2388 202 9 60 25 134 9
2308 3.36 0 15.49 28.8 0 25.44 0 0 949 949 360 325 9 730 10.4 1200
  72 13.5 262 2388 202 9 60 25 134 9
2309 0 1.6 14.4 1.6 3.2 8 1.6 1.6 949 949 360 325 9 730 10.4 1200
  72 13.5 262 2388 202 9 60 25 134 9
2310 0 0 15.36 0 0 11.52 0 18.24 949 949 360 325 9 730 10.4 1200
  72 13.5 262 2388 202 9 60 25 134 9
2311 0 7.6 25.44 3.36 0 3.36 0 6.24 949 949 360 325 9 730 10.4 1200
  72 13.5 262 2388 202 9 60 25 134 9
2312 2.24 0 25.76 4.48 2.24 11.69 0 16.64 949 949 360 325 9 730 10.4 1200
  72 13.5 262 2388 202 9 60 25 134 9
2313 8.64 3.36 25.28 3.36 0 3.36 0 0 949 949 360 325 9 730.10.4 1200
  72 13.5 262 2388 202 9 60 25 134 9
2314 2 0 26 0 2 8 0 2 949 949 360 325 9 730 10.4 1200
  72 13.5 262 2388 202 9 60 25 134 9
2315 2 0 16.4 4 8 0 10 949 949 360 325 9 730 10.4 1200
  72 13.5 262 2388 202 9 60 25 134 9
2316 1.92 1.92 39.08 1.92 0 8.16 0 0 949 949 360 325 9 730 10.4 1200
  72 13.5 262 2388 202 9 60 25 134 9
2317 2 1 33.24 2.4 0 7.28 0 .24 949 949 360 325 9 730 10.4 1200
  72 13.5 262 2388 202 9 60 25 134 9
2318 0 0 32.52 6.16 2.24 10.08 0 0 949 949 360 325 9 730 10.4 1200
  72 13.5 262 2388 202 9 60 25 134 9
2319 0 0 37.84 0 0 8.16 0 0 949 949 360 325 9 730 10.4 1200
  72 13.5 262 2388 202 9 60 25 134 9
2320 0 7.8 40.2 1.8 0 10.2 0 0 949 949 360 325 9 730 10.4 1200
  72 13.5 262 2388 202 9 60 25 134 9
```

Transformed Housing Data

```
1100 1.9 0 1.65 2.. .6. 3.63 . 1. 4.64 113.5 8 175 7 34 3.4 49.8
  32.9 9 3.4 7 24 20 11 24.5 124 833
1101 1.9 .42 2.59 2.37 5.23 0 0 .56 2.04 113.5 8 175 7 34 3.4 49.8
  32.9 9 3.4 7 24 20 11 24.5 124 833
1102 .73 0 0 0 0 0 .78 0 15.44 113.5 8 175 7 34 3.4 49.8
  32.9 9 3.4 7 24 20 11 24.5 124 833
1103 1.3 .42 .72 2.37 0 0 0 0 6.07 113.5 8 175 7 34 3.4 49.8
  32.9 9 3.4 7 24 20 11 24.5 124 833
1104 1.14 0 1.19 0 .54 .36 1.27 .56 7.44 113.5 8 175 7 34 3.4 49.8
  32.9 9 3.4 7 24 20 11 24.5 124 833
1105 .35 0 3.4 2.37 0 0 0 0 8.64 113.5 8 175 7 34 3.4 49.3
  32.9 9 3.4 7 24 20 11 24.5 124 833
1106 .36 .41 .72 4.79 0 1.3 .78 0 9.6 113.5 8 175 7 34 3.4 49.8
  32.9 9 3.4 7 24 20 11 24.5 124 833
1107 2.74 0 2.36 0 0 .67 9 1.33 4 113.5 8 175 7 34 3.4 49.8
  32.9 9 3.4 7 24 20 11 24.5 124 833
1108 1.13 0 2.6 0 0 .46 2.44 1.33 3.36 113.5 8 175 7 34 3.4 49.8
  32.9 9 3.4 7 24 20 11 24.5 124 832
1109 2.59 1.77 0 0 0 0 2.34 .66 4.64 113.5 8 175 7 34 3.4 49.8
  32.9 9 3.4 7 24 20 11 24.5 124 833
1110 3.2 0 1 0 0 0 .54 1.5 1.8 113.5 8 175 7 34 3.4 49.8
  32.9 9 3.4 7 24 20 11 24.5 124 833
1111 1.13 0 1.50 0 0 1 0 2.7 2.04 113.5 8 175 7 34 3.4 49.8
  32.9 9 3.4 7 24 20 11 24.5 124 833
1112 0 1.32 0 0 3 0 2.2 1 2.34 113.5 8 175 7 34 3.4 49.8
  32.9 9 3.4 7 24 20 11 24.5 124 833
1113 .48 0 2 0 1.56 .88 1.46 0 2.4 113.5 8 175 7 34 3.4 49.8
  32.9 9 3.4 7 24 20 11 24.5 124 833
1114 0 0 1.31 0 0 0 2.78 1.62 3.72 113.5 8 175 7 34 3.4 49.8
  32.9 9 3.4 7 24 20 11 24.5 124 833
1115 0 0 1.14 0 0 2.14 2.45 2.12 2.04 113.5 8 175 7 34 3.4 49.8
  32.9 9 3.4 7 24 20 11 24.5 124 833
1116 1.13 0 1.5 0 .84 0 1.24 2.12 2.64 113.5 8 175 7 34 3.4 49.8
  32.9 9 3.4 7 24 20 11 24.5 124 832
1117 .9 0 1.34 0 .72 2.52 1.02 1.75 2.4 113.5 8 175 7 34 3.4 49.9
  32.9 9 3.4 7 24 20 11 24.5 124 833
1118 0 0 1.23 0 1.44 .76 1.83 2.37 2.28 113.5 8 175 7 34 3.4 49.8
  32.9 9 3.4 7 24 20 11 24.5 124 833
1119 0 0 0 0 0 0 0 0 12 113.5 8 175 7 34 3.4 49.8
  32.9 9 3.4 7 24 20 11 24.5 124 833
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  95 7.5 1.67 41.5 78 32 25 117 63
1202 .5 0 3.39 0 3.24 0 .57 1.13 1.38 39 5 86 7 35 3.75 74.5 44
  95 7.5 1.67 41.5 78 32 25 117 63
1203 3 .74 3.55 0 0 0 .6 1.21 2.34 39 5 86 7 35 3.75 74.5 44
  95 7.5 1.67 41.5 78 32 25 117 63
1204 1.34 .73 1.62 0 2.37 1.44 .19 1.85 4.5 39 5 86 7 35 3.75 74.5 44
  95 7.5 1.67 41.5 78 32 25 117 63
1205 .9 1.93 .76 0 2.11 0 1.9 .45 2.24 39 5 86 7 35 3.75 74.5 44
  95 7.5 1.67 41.5 78 32 25 117 63
1206 1.57 4.55 1.35 0 0 1.45 1 1.21 2.34 39 5 86 7 35 3.75 74.5 44
  95 7.5 1.67 41.5 78 32 25 117 63
1207 1.57 3.45 .51 0 2.39 0 .37 3.18 2.34 39 5 86 7 35 3.75 74.5 44
  95 7.5 1.67 41.5 78 32 25 117 63
1208 .5 0 2.4 0 .7 0 0 3.05 3.4 39 5 86 7 35 3.75 74.5 44
  95 7.5 1.67 41.5 78 32 25 117 63
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  95 7.5 1.67 41.5 78 32 25 117 63
1210 0 4.1 1.73 0 .36 0 1.18 .5 2.52 39 5 86 7 35 3.75 74.5 44
  95 7.5 1.67 41.5 78 32 25 117 63
1211 1.34 0 1.34 0 .74 0 1.18 .5 .72 39 5 86 7 35 3.75 74.5 44
  95 7.5 1.67 41.5 78 32 25 117 63
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  95 7.5 1.67 41.5 78 32 25 117 63
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  95 7.5 1.67 41.5 78 32 25 117 63
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1216 2.54 0 0 0 0 0 3.10 0 0 39 5 86 7 35 3.75 74.5 44
  95 7.5 1.67 41.5 78 32 25 117 63
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  95 7.5 1.67 41.5 78 32 25 117 63
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  95 7.5 1.67 41.5 78 32 25 117 63
1301 .41 2.45 0 0 3.1 0 0 0 1.92 81 8.2 88 0 71 14 36.75 25 14.85
  2.22 1.67 22 100.6 13.3 171 21 9
1302 1.44 1.41 1.77 0 1.37 0 1.46 0 0 81 8.2 88 0 71 14 36.75 25 14.85
  2.22 1.67 22 100.6 13.3 171 21 9
1303 1.04 2.28 0 0 1.3 1.28 4.14 0 0 81 8.2 88 0 71 14 36.75 25 14.85
  2.22 1.67 22 100.6 13.3 171 21 9
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  2.22 1.67 22 100.6 13.3 171 21 9
1305 1.21 0 0 0 2.36 0 0 0 6 81 8.2 88 0 71 14 36.75 25 14.85
  2.22 1.67 22 100.6 13.3 171 21 9
1306 2.07 2.6 0 0 1.92 1.41 0 0 0 81 8.2 88 0 71 14 36.75 25 14.85
  2.22 1.67 22 100.6 13.3 171 21 9
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  2.22 1.67 22 100.6 13.3 171 21 9
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  2.22 1.67 22 100.6 13.3 171 21 9
1309 2.74 0 .72 0 .72 .72 0 0 2.4 81 8.2 88 0 71 14 36.75 25 14.85
  2.22 1.67 22 100.6 13.3 171 21 9
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  2.22 1.67 22 100.6 13.3 171 21 9
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  2.22 1.67 22 100.6 13.3 171 21 9
1312 .76 0 1.4 0 0 0 2.08 0 0 81 8.2 88 0 71 14 36.75 25 14.85
  2.22 1.67 22 100.6 13.3 171 21 9
1313 .95 0 1.3 0 2.36 0 0 0 1.92 81 8.2 88 0 71 14 36.75 25 14.85
  2.22 1.67 22 100.6 13.3 171 21 9
1314 1.6 0 1.38 0 .81 0 0 0 2.69 81 8.2 88 0 71 14 36.75 25 14.85
  2.22 1.67 22 100.6 13.3 171 21 9
1315 0 0 1.4 0 1.9 2.32 0 2.49 0 81 8.2 88 0 71 14 36.75 25 14.85
  2.22 1.67 22 100.6 13.3 171 21 9
1316 0 .81 1.2 2.0 2.5 0 0 0 81 8.2 88 0 71 14 36.75 25 14.85
  2.22 1.67 22 100.6 13.3 171 21 9
1317 0 0 7.6 0 .44 .42 0 0 0 81 8.2 88 0 71 14 36.75 25 14.85
  2.22 1.67 22 100.6 13.3 171 21 9
1318 0 0 1 0 0 2.22 0 0 13.68 81 8.2 88 0 71 14 36.75 25 14.85
  2.22 1.67 22 100.6 13.3 171 21 9
1319 .2 .47 1.44 0 .4 .44 0 0 .44 81 8.2 88 0 71 14 36.75 25 14.85
  2.22 1.67 22 100.6 13.3 171 21 9
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  2.22 1.67 22 100.6 13.3 171 21 9
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Transformed Service Data

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  343 57.6 904.8 0 0 5.5 800
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  343 57.6 904.8 0 0 5.5 800
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  343 57.6 904.8 0 0 5.5 800
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  343 57.6 904.8 0 0 5.5 800
2109 0 0 6.08 0 8 0 1.28 .64 121 121 151 9 79 9 2.7 800 10 0 102
  343 57.6 904.8 0 0 5.5 800
2110 0 0 4.64 0 8 .64 .64 2.08 121 121 151 9 79 9 2.7 800 10 0 102
  343 57.6 904.8 0 0 5.5 800
2111 0 0 3.36 0 .96 4.32 .48 2.88 121 121 151 9 79 9 2.7 800 10 0 102
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  343 57.6 904.8 0 0 5.5 800
2113 .48 .48 .48 0 4.56 .48 .48 4.56 121 121 151 9 79 9 2.7 800 10 0 102
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  343 57.6 904.8 0 0 5.5 800
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  343 57.6 904.8 0 0 5.5 800
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  57 627 47 202 5 5 25 150
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2203 0 .56 7.84 0 .56 0 0 5.04 77 77 109 80 63.2 50 1.98 780 14 0
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2204 0 0 3.64 2.94 0 1.54 0 5.88 77 77 109 80 63.2 50 1.98 780 14 0
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  57 627 47 202 5 5 25 150
2208 2.38 1.12 3.6 1.12 0 .56 0 5.32 77 77 109 80 63.2 50 1.98 780 14 0
  57 627 47 202 5 5 25 150
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  57 627 47 202 5 5 25 150
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  57 627 47 202 5 5 25 150
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2212 0 0 3.24 1.08 .6 1.68 0 5.4 77 77 109 80 63.2 50 1.98 780 14 0
  57 627 47 202 5 5 25 150
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  57 627 47 202 5 5 25 150
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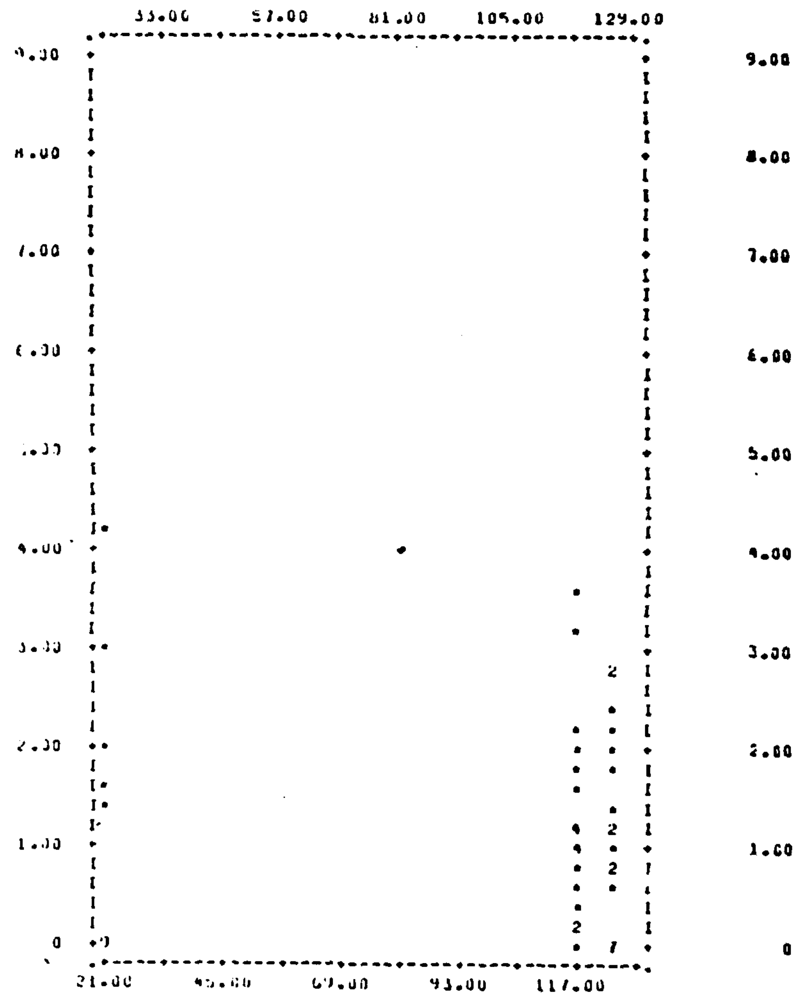
  72 13.5 [illegible] 2388 262 9 60 25 134 9
```

Appendix K: Representative Scatterplot of Job Category and Workload Factors Relationships

SCATTERGRAM OF (DOWN) MRC MAINT REPAIR CONST WORK -CAT
(ACROSS) PROFAC NUMBER OF PROPOSED FACILITIES -WCF



STATISTICS..

CORRELATION (R)-	.23948	R SQUARED -	.05735
SIGNIFICANCE R -	.03267	STD ERR OF EST -	1.09466
INTERCEPT (A) -	.50367	STD ERROR OF A -	.28462
SIGNIFICANCE A -	.04102	SLOPE (B) -	.00539
STD ERROR OF B -	.00287	SIGNIFICANCE B -	.03267

PLOTTED VALUES - 60 EXCLUDED VALUES - 0 MISSING VALUES - 0

Appendix L: Tables of Intercorrelation - Multicorrelation Matrix

CORRELATION COEFFICIENTS.

A VALUE OF 99.00000 IS PRINTED
IF A COEFFICIENT CANNOT BE COMPUTED.

CUST	-.28179		
OFFICE	-.24365	.85930	
LIST	-.25675	.83001	.46271
	HRO	CUST	OFFICE

MFHSPA	-.12606	
BASE1	-.13067	.98223
	MFH	MFHSPA

SPACES	-.00902			
UPHSUP	-.00845	.99999		
TRANSUP	-.01424	.99911	.99891	
BASE2	-.01424	.99911	.99891	1.00000
	UPH	SPACES	UPHSUP	TRANSUP

COLVAL	-.29541	
BUDGETS	.05415	-.41709
	FUNDS	COLVAL

ACTNUM	.03764	
ACTVAL	-.10952	.34135
	FURNISH	ACTNUM

CURFAC	-.24409	
PROFAC	.23949	-.99832
	MRC	CURFAC

SUSNO	.24825
	SUSP

	COM	POP	SALEVOL1
POP	.09876		
SALEVOL1	.09876	1.00000	
CORR1	.09876	1.00000	1.00000

	AAFES	POPA	SALEVOL2
POPA	99.00000		
SALEVOL2	99.00000	99.00000	
CORR2	99.00000	99.00000	99.00000

	FOOD	MEALS	RATIONS
MEALS	-.03403		
RATIONS	-.00471	.99804	
FACILITY	.08290	.76349	.79334

	MORTUARY	CASES
CASES	-.21748	
HONORS	.00946	.40179

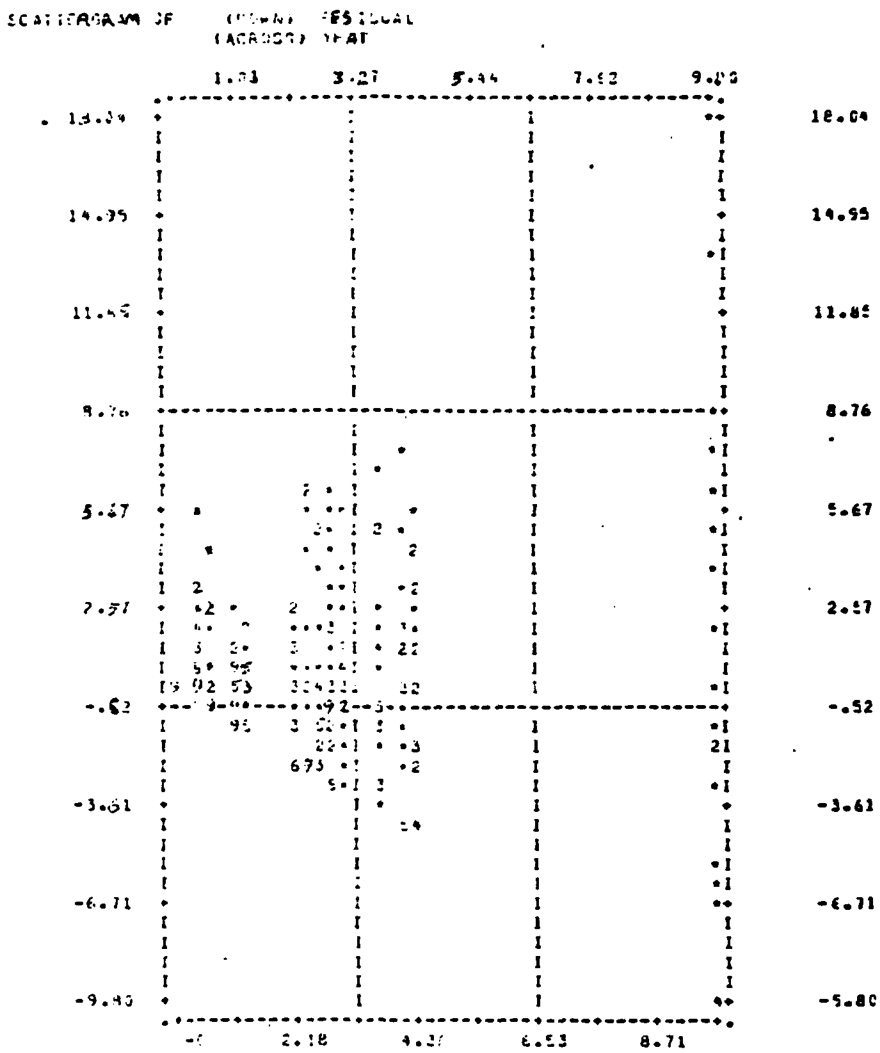
	LAUNDRY	UPHSUP
UPHSUP	-.49788	
CONTRA2	.49788	-1.00000

	RIGS	TEAMS	DEPLOY
TEAMS	.13028		
DEPLOY	.23248	.95151	
HOURS	.20178	.97778	.99485

	SUSP
SUSNO	.24355

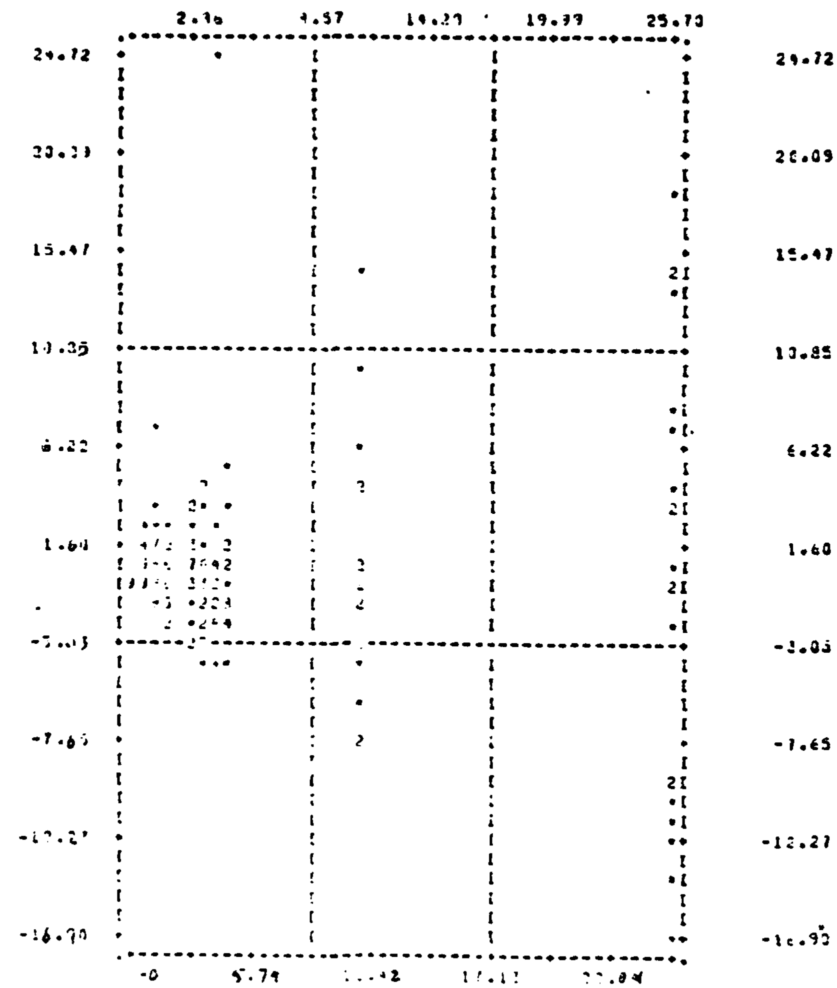
Appendix M: Scatterplot of Cumulative Residual Values

Untransformed Housing Data

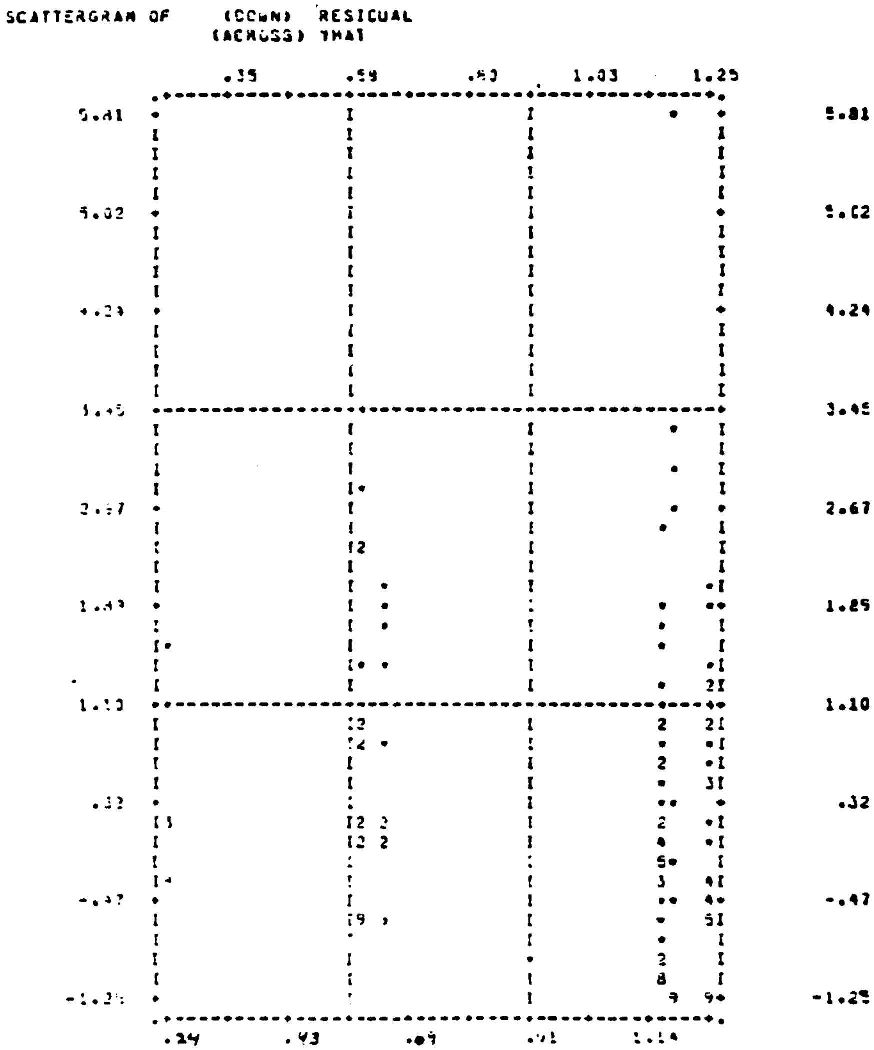


Untransformed Service Data

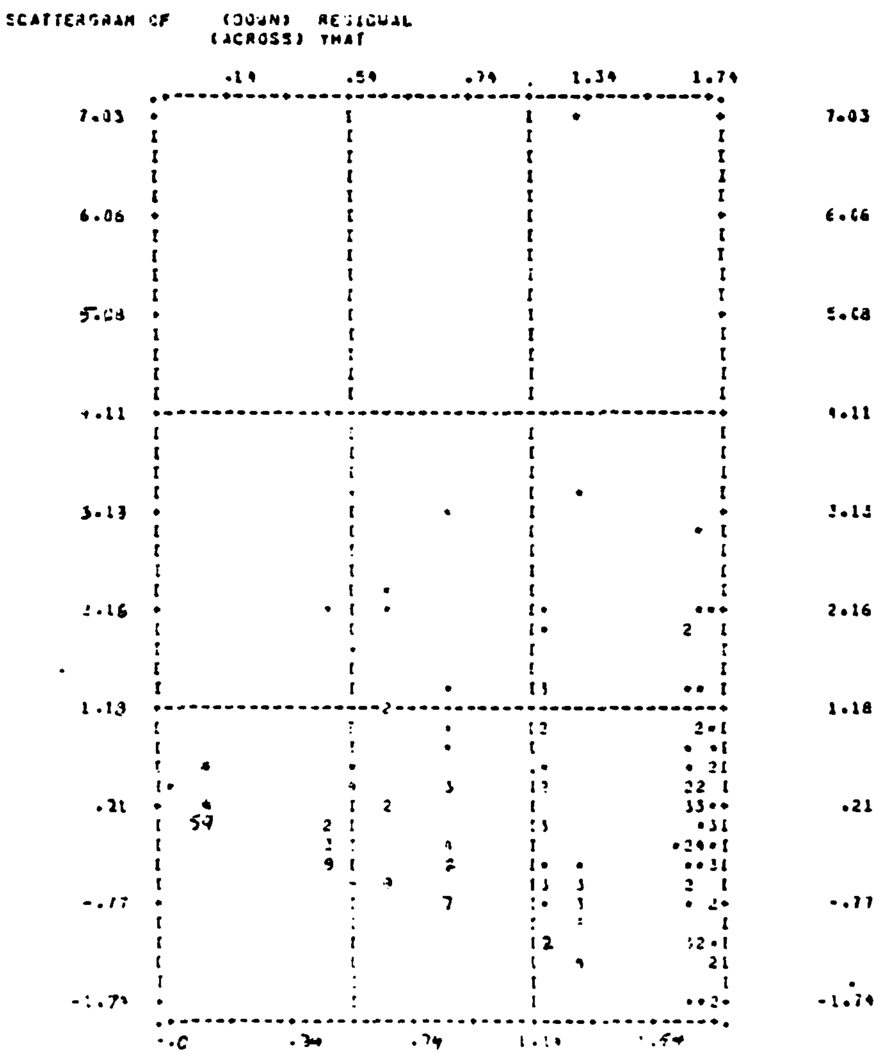
SCATTERGRAM OF (DOWN) RESIDUAL
(ACROSS) YHAT



Transformed Housing Data



Transformed Service Data



Appendix N: Tables of Statistically Significant Models

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* * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * *

DEP. VAR... RIMS      . PRIME RIMS MOBILITY -CAT

PARAMETERS..  MAXIMUM STEP     6     F TO ENTER        2.800
              TOLERANCE    .0010     F TO REMOVE       2.790

MEAN RESPONSE          1.42733      STD. DEV.        1.10501

VARIABLE(S) ENTERED ON STEP    1
DEPLOY       PRIME RIMS DEPLOYMENTS -WLF

MULTIPLE R       .2325 ANOVA            DF   SUM SQUARES  MEAN SQ.       F
R SQUARE         .0540 REGRESSION       1.         3.894     3.894     3.314
STD DEV         1.0840 RESIDUAL        58.        68.148     1.175 SIG. .074
ADJ R SQUARE     .0377 COEFF OF VARIABILITY       75.9PCT

VARIABLE            B        S.E. B        F      SIG.        BETA   ELASTICITY

DEPLOY            .073        .040       3.314   .074       .23248     .16303
CONSTANT         1.195        .190      39.730   .000


* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

VARIABLE(S) ENTERED ON STEP    2
TEAMS        PRIME RIMS TEAM NUMBERS -WLF

MULTIPLE R       .3761 ANOVA            DF   SUM SQUARES  MEAN SQ.       F
R SQUARE         .1414 REGRESSION       2.        10.188     5.094     4.694
STD DEV         1.0417 RESIDUAL        57.        61.853     1.085 SIG. .013
ADJ R SQUARE     .1113 COEFF OF VARIABILITY       73.0PCT

VARIABLE            B        S.E. B        F      SIG.        BETA   ELASTICITY

DEPLOY            .362        .128       8.262   .006      1.14682     .80420
TEAMS            -.138        .057       5.401   .019      -.96093    -.39643
CONSTANT          .845        .233      13.181   .001

F-LEVEL OR TOLERANCE-LEVEL INSUFFICIENT FOR FURTHER COMPUTATION.
```

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* * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * *

DEP. VAR... MORTUARY   MORTUARY AFFAIRS FUNCTION -CAT

PARAMETERS..  MAXIMUM STEP    4     F TO ENTER        2.800
              TOLERANCE   .0010     F TO REMOVE       2.790

MEAN RESPONSE         1.01717      STD. DEV.       1.43274

VARIABLE(S) ENTERED ON STEP   1
CASES       MORTUARY AFFAIRS CASELOAD -WLF

MULTIPLE R      .2175 ANOVA          DF   SUM SQUARES  MEAN SQ.       F
R SQUARE        .0473 REGRESSION     1.        5.729      5.729     2.880
STD DEV        1.4104 RESIDUAL      58.      115.383      1.989 SIG. .095
ADJ R SQUARE    .0309 COEFF OF VARIABILITY   138.7PCT

VARIABLE         B       S.E. B       F      SIG.       BETA    ELASTICITY

CASES          -.006      .004     2.880   .095     -.21748    -.52366
CONSTANT       1.550      .363    18.240   .000

F-LEVEL OR TOLERANCE-LEVEL INSUFFICIENT FOR FURTHER COMPUTATION.
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* * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * *

DEP. VAR... LAUNDRY.   LAUNDRY AND DRY CLEANING RESP -CAT

PARAMETERS..  MAXIMUM STEP    4     F TO ENTER        2.800
              TOLERANCE   .0010     F TO REMOVE       2.790

MEAN RESPONSE         1.10275      STD. DEV.       1.13248

VARIABLE(S) ENTERED ON STEP   1
CONTRA2     $ VALUE LAUNDRY CONTRACTS -WLF

MULTIPLE R      .4[illegible] ANOVA          DF   SUM SQUARES  MEAN SQ.       F
R SQUARE        .2473 REGRESSION     1.       12.399     12.399    12.524
STD DEV         .9[illegible] RESIDUAL      38.       37.619       .990 SIG. .001
ADJ R SQUARE    .2[illegible]1 COEFF OF VARIABILITY    90.2PCT

VARIABLE         B       S.E. B       F      SIG.       BETA    ELASTICITY

CONTRA2         .014      .004    12.524   .001      .49788    4.56880
CONSTANT      -3.[illegible]36     1.432     7.550   .009

F-LEVEL OR TOLERANCE-LEVEL INSUFFICIENT FOR FURTHER COMPUTATION.
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VITA

First Lieutenant Mark H. Bailey was born on 29 March 1958 in Kansas City, Missouri. Upon graduation from a Wilmette, Illinois high school in 1976, he entered Purdue University. He received a Bachelor of Science in Industrial Engineering in May 1980 from the university. He was commissioned upon graduation through the Air Force Reserve Officers Training Corps, having been named a Distinguished Graduate. He entered active duty in September 1980 at Hancock Field, New York, assigned to Base Civil Engineering as Chief, Industrial Engineering Branch. While at Hancock Field, he spent nearly two and a half years identifying, coordinating, and planning requirements and actions for the deactivation of the installation. Because of a delay in deactivation, he departed Hancock Field for an assignment to the Air Force Institute of Technology (AFIT) and entered AFIT's School of Systems and Logistics in May 1983.

Permanent Address: 2532 The Strand
Northbrook, Illinois 60062

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